BRITISH COLUMBIA
OFFSHORE OIL AND GAS
TECHNOLOGY UPDATE

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BRITISH COLUMBIA OFFSHORE OIL AND GAS TECHNOLOGY UPDATE

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October 19, 2001

PREFACE

In 1998, the British Columbia Information, Science and Technology Agency, on behalf of the Premier's Advisory Council on Science and Technology, tendered and issued a contract to AGRA Earth and Environmental Limited (AGRA) (St. John's, Newfoundland office) to review and report on offshore development technologies. The AGRA study examined the status of the offshore exploration industry in both Canada and elsewhere, particularly as it related to the issues identified in the Envrionmental Assessment Panel Report on offshore oil and gas issues dated 1986. The 1998 report was not released by the Province. Specific objectives of the 1998 report were to provide the Premier's Advisory Council on Science and Technology with:

- the status of the offshore exploration industry in Canada and elsewhere;
- information regarding the status of offshore issues as they relate to issues identified in the 1986 Panel Report; and
- a review of advancements in the field and experience in other jurisdictions which would be applicable to British Columbia and a summary of information gaps that might prevent a full assessment of oil and gas exploration and development risks and impacts.

The Province of British Columbia has recently committed to review the existing moratorium on offshore oil and gas development. As the lead coordinating agency for oil and gas resources off the coast of British Columbia, the Ministry of Energy and Mines issued a Request for Proposals on August 20, 2001 to prepare an update of the 1998 AGRA report using existing information and literature. The intent of this update report is to document background information for use by the government in reviewing the moratorium. The scope of work for this contract was specifically to:

- review the 1986 panel report (Offshore Hydrocarbon Exploration, a Report and Recommendations of the West Coast Offshore Exploration Environmental Assessment Panel) and the 1998 AGRA report (Review of Offshore Development Technologies); and
- update the 1998 review to consider additional scientific and technological advancements, changes in regional economics and developments in other jurisdictions.

The focus of this update was on offshore oil and gas engineering, environment and socio-economic factors, and state-of-the-art technologies. As this is an update of the 1998 AGRA report and not a new study, the project team used portions of the previous text. Those segments of the 1998 report that are incorporated verbatim, or with minor edits, have been italicized for clear identification. Rather than address specific changes that have occurred between 1986 and 2001 or between 1998 and 2001, this update has focussed on updating the information in the AGRA report and addressing data and information gaps with an emphasis on current issues and future trends in the offshore industry in Canada and around the world. This report is not intended to be a comprehensive assessment of all available engineering technologies and approaches to the design of offshore structures or an environmental impact assessment of offshore oil and gas activities. Rather, it is intended to be a background report summarizing the latest technologies, their application to the safety of offshore oil and gas operations and potential environmental effects of offshore oil and gas activities. This report is intended to be a "stand alone" document and the reader should not have to refer to the previous reports to understand the issues.

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION 1

1.1 Canadian Offshore Oil and Gas Production in a Global Context 4

2.0 REGULATORY REGIME 5

2.1 Oil and Gas Commission 5

2.2 British Columbia Environmental Assessment Process 7

2.2.1 Concurrent Regulatory Approvals 11

2.2.2 Public Consultation 11

2.2.3 Federal Environmental Impact Assessment 12

2.3 Atlantic Canada 13

2.3.1 Roles of the Boards 13

2.3.2 Development Application Process 15

2.3.3 Joint Offshore Board/Canadian Environmental Assessment Act Process 18

2.3.4 Joint NEB/CEAA/Board Process 20

2.3.5 Other Approval Processes 21

2.3.6 Lessons Learned 22

3.0 REGIONAL SETTING 23

3.1 Marine Coastal Biodiversity/Continental Shelf Biota 23

3.1.1 Ecosystems 23

3.1.2 Finfish and Shellfish 23

3.1.3 Seabirds 24

3.1.4 Marine Mammals 26

3.2 Commercial Fishery 27

3.2.1 Salmon 27

3.2.2 Herring 28

3.2.3 Halibut 28

3.2.4 Groundfish 28

3.2.5 Shellfish 29

3.2.6 Commercial Sport Fishery 29

3.2.7 Aquaculture 29

3.3 First Nations 30

3.3.1 Populations 30

3.3.2 Position Statements 32

3.4 Communities 33

3.4.1 People 33

3.4.2 Fisheries 37

3.4.3 Challenges Facing Coastal Communities 37
3.5 Other Resource Use - Tourism, Sensitive Areas, Port and Shipping 38
3.5.1 Tourism 38
3.5.2 Sensitive Areas - Marine Protected Areas (MPAs) 40
3.5.3 Land and Resource Management Plans (LRMP) 42
3.5.4 Port and Shipping Activities 44

4.0 PHYSICAL ENVIRONMENT 45

4.1 Physiography 45
4.1.1 Bathymetry 46
4.1.2 SEAMAP 48
4.2 Climate 49
4.2.1 El Niño and La Niña 50
4.3 Water Level and Ocean Currents 50
4.4 Storm Events 54
4.4.1 Winds 55
4.4.2 Surface Waves 57
4.4.3 Wind-Driven Currents 58
4.4.4 West Coast Marine Weather Forecasting 59
4.5 Gas Hydrates 62
4.6 Faulting and Earthquakes 62
4.6.1 Accelerations and Ground Motion 64
4.6.2 Tsunamis 65
4.7 Fault Movement, Slope Stability and Liquefaction Potential 65
4.8 Summary 66

5.0 ENGINEERING 67

5.1 Seismic and Geophysical Surveys 67
5.1.1 Seismic Survey 68
5.1.2 Supplementary Geophysical Information 69
5.1.3 Seabed Mapping Technologies 70
5.1.4 Information Technology 78
5.1.5 Noise Issues in Geophysical Survey and Exploratory Drilling 79
5.2 Drilling Technology in Offshore E&P 80
5.2.1 Horizontal and Multilateral Direction Drilling 85
5.2.2 Slimhole and Casing Drilling 86
5.2.3 Riserless Drilling or Dual Gradient Drilling (DGD) 86
5.2.4 Advanced Mooring and Dynamic Positioning 87
5.2.5 Design Improvements for BOP, Top Drive and Mud Pump 87
5.2.6 Platform Discharges 88
5.3 Development, Operations and Decommissioning 90

5.4 Performance and Risk 92
5.4.1 Earthquake Risk and Performance *92*
5.4.2 Spill *93*
5.4.3 Blowout *95*
5.4.4 Miscellaneous Accidents *96*
5.4.5 Risk Based Design Procedures *96*
5.4.6 Health and Safety Issues *97*
5.5 Summary... 97

6.0 BIOLOGICAL/ECOLOGICAL ENVIRONMENT 97

6.1 Issues and Possible Effects 98
6.1.1 Presence of Structures *98*
6.1.2 Lights and Flares *98*
6.1.3 Discharges *100*
6.1.4 Vessel Traffic *106*
6.1.5 Atmospheric Emissions *107*
6.1.6 Helicopter Traffic *109*
6.1.7 Noise *110*
6.1.8 Seismic Surveys *110*
6.1.9 Oil Spills [Accidental Events] *113*
6.2 Mitigation.. 120
6.3 Environmental Management Systems 122
6.4 Environmental Effects Monitoring 124
6.4.1 Program Design and Implementation *124*
6.4.2 Results of Atlantic Canada EEM Programs *125*
6.5 Cumulative Effects 126
6.5.1 Canadian East Coast Experience *127*
6.5.2 American Experience *134*

7.0 SOCIO-ECONOMIC CONSIDERATIONS 141

7.1 The Four Main Phases Of Oil And Gas Activity 141
7.1.1 Exploration *142*
7.1.2 Development *144*
7.1.3 Production *146*
7.1.4 Decommissioning *147*
7.1.5 Other *147*
7.2 Socio-Economic Management Strategies 148
7.2.1 Control *148*
7.2.2 The Objectives of Managing and Monitoring *148*
7.2.3 Balancing Revenues and Direct Benefits *149*
7.3 Issues..... 150

7.3.1 Regional Economic Development *151*
7.3.2 Commercial Fisheries *153*
7.3.3 Fisheries Compensation *154*
7.3.4 Education/Training *155*
7.3.5 Employment *157*
7.3.6 Business Opportunities, Industrial Development and Infrastructure *160*
7.3.7 Research Needs *162*
7.3.8 Investment *163*
7.3.9 Social Effects *163*
7.4 Current Community Concerns 165
7.5 Alaska 167
7.6 Lessons Learned 169
8.0 CONCLUSIONS 171
9.0 CLOSURE 173
10.0 REFERENCES 174

LIST OF APPENDICES

Appendix 1 Summary of DFO's HADD Compensation Process
Appendix 2 First Nations Positions on the Offshore Oil and Gas Moratoriums
Appendix 3 Summary of Cumulative Effects Assessment for Offshore Oil and Gas Exploration and Development Activities in US Federal Waters

LIST OF TABLES

		Page No.
Table 2.1	OGC Applications Identification Table	8
Table 3.1	Status of Seabird in British Columbia and their Distribution	25
Table 3.2	Distribution of Active Grow-Out Sites by Regional	30
Table 3.3	Populations of Coastal First Nations in the BC Treaty Process	32
Table 3.4	Income and Sector Dependency, Selected Centres	34
Table 3.5	District Population Statistics	35
Table 3.6	Key Infrastructure and Major Employment Industries	36
Table 3.7	Labour Characteristics by District	36
Table 3.8	Tourism in Selected Centres	39
Table 3.9	Rail, Road and Port Infrastructure, Selected Centres	44
Table 4.1	Design Parameters For Typical Drilling Units (Petro-Canada 1983)	54
Table 4.2	Parameters Reported At Marine Weather Observation Stations (After AGRA 1998)	56
Table 5.1	Sub-Sea Noise Levels	79
Table 5.2	Drilling Issues and Available Technology	84
Table 5.3	Performance of a few platforms in earthquakes	93
Table 5.4	Canadian Offshore Spill Data	94
Table 5.5	Occupational Health and Safety	97
Table 6.1	Daily Emissions from a SEDCO 712 and its Support Equipment	108
Table 6.2	Summary of Effects from Air Gun Operations on Whales, Sea Turtles and Fish	112
Table 6.3	Important Exploration Well Statistics from World-Wide, Gulf of Mexico, Offshore Norway North Sea and UK North Sea	114
Table 6.4	Important Development/Production Well Statistics from World-Wide, Gulf of Mexico, Offshore Norway North Sea and UK North Sea	114
Table 6.5	Summary of Effects of Oil on Marine Environment	119

LIST OF FIGURES

Page No.

Figure 1.1 Exploration Well Locations 2
Figure 1.2 North Coast Offshore British Columbia Oil and Gas Tenures 3
Figure 3.1 Coastal First Nations in the BC Treaty Process 31
Figure 4.1 Oil and gas plays on the west coast. 46
Figure 4.2 Oblique shaded-relief depiction of the topography and 47
Figure 4.3 Current meter mooring sites for the period 1982 through 1995. 52
Figure 4.4 Maximum tidal current speeds in northern British Columbia water. 53
Figure 4.5 Locations of land-based marine weather reporting stations (including MAREP station) and marine weather buoys in northern British Columbia waters. 56
Figure 4.6 Weather forecast areas for British Columbia marine waters 60
Figure 4.7 Seismicity and Faulting around the Queen Charlotte Islands 63
Figure 5.1 Colour-banded bathymetric map developed from multibeam data collected near Werner Bay, Queen Charlotte Islands 72
Figure 5.2 Morphology (top) and slope angle (middle) images and depth profile (bottom) of the southern failure lobe at Mapleguard Spit on Vancouver Island. 73
Figure 5.3 Sidescan sonar mosaic of the Grief Point landslide 74
Figure 5.4 Multibeam bathymetry and acoustic seabed classification from single beam echosounder for Race Rocks, British 75
Figure 5.5 High resolution seismic reflection profile crossing the Grief Point submarine landslide... 76
Figure 5.6 Sponge reef in Hecate Strait. 77
Figure 5.7 Offshore Drilling Units 80
Figure 5.8 Water Depths in the Offshore Lease Areas 81
Figure 5.9 Water Depths in the Offshore Oil and Gas Exploration and Production 82
Figure 5.10 A Truss-SPAR Rig is Being Transported 83
Figure 5.11 Multilateral-Horizontal Wells in the Zuata Field, Faja, Venezuela 86
Figure 5.12 Oil in the Sea..... 93
Figure 5.13 Causes of Large Spill in US OCS 94

1.0 INTRODUCTION

In 1958, the first offshore seismic activity took place in the Queen Charlotte Basin off Canada's west coast. A moratorium was imposed on exploration drilling in the coastal waters between Vancouver Island and Alaska by the Province of British Columbia in 1959. *By 1961 Shell Canada Limited had begun acquiring exploration permits for offshore areas in Hecate Strait, Queen Charlotte Sound and on the continental shelf off the western coast of Vancouver Island. This led the company to conduct geological mapping and offshore seismic surveys between 1963 and 1967.* The Province's moratorium was lifted in 1966 and between 1967 and 1969 *Shell drilled 14 wells, eight of which were in the Hecate Strait - Queen Charlotte Sound.* The locations of these wells is shown on Figure 1.1. *By 1970 Shell had entered into a farm-out agreement with Chevron Canada Resources whereby Chevron would earn an interest in the Shell offshore area by conducting seismic surveys and drilling two deep exploratory wells.* Offshore British Columbia oil and gas lease tenures as of 2001 are shown on Figure 1.2. *However, exploration soon came to a standstill. In 1972 the federal government imposed a moratorium preventing crude oil tankers en route from the Trans-Alaska pipeline terminal at Valdez, Alaska from travelling through the Dixon Entrance, Hecate Strait and Queen Charlotte Sound. Shortly afterwards, the federal government placed a moratorium on drilling in these waters. In 1981, the Province of British Columbia declared the region an Inland Marine Zone. Simultaneously, a moratorium was placed on offshore exploration in Johnstone Strait south of Telegraph Cove and in the Straits of Georgia and Juan de Fuca. These moratoria remain in effect today.*

Consideration was given to lifting the moratorium in 1984 to allow the petroleum companies holding leases in the region to undertake exploration programs. A five person panel was appointed and held public information meetings and public hearings throughout northern coastal British Columbia during the fall of 1984 and 1985 respectively. Chevron Canada Resources Ltd. acted as a proponent and Petro-Canada initially participated but withdrew in November 1984. Based on information obtained at those meetings, the Panel delivered its report in April 1986. Entitled "Offshore Hydrocarbon Exploration, a Report and Recommendations of the West Coast Offshore Exploration Environmental Assessment Panel", the report contained 92 (ninety-two) recommendations covering a broad spectrum of issues including:

- *the environmental assessment process;*
- *seismic surveying;*
- *routine exploratory drilling and support operations;*
- *socio-economic effects of routine operations;*
- *hydrocarbon blowouts;*
- *fate and effects of oil in the marine environment;*
- *oil blowout contingency;*

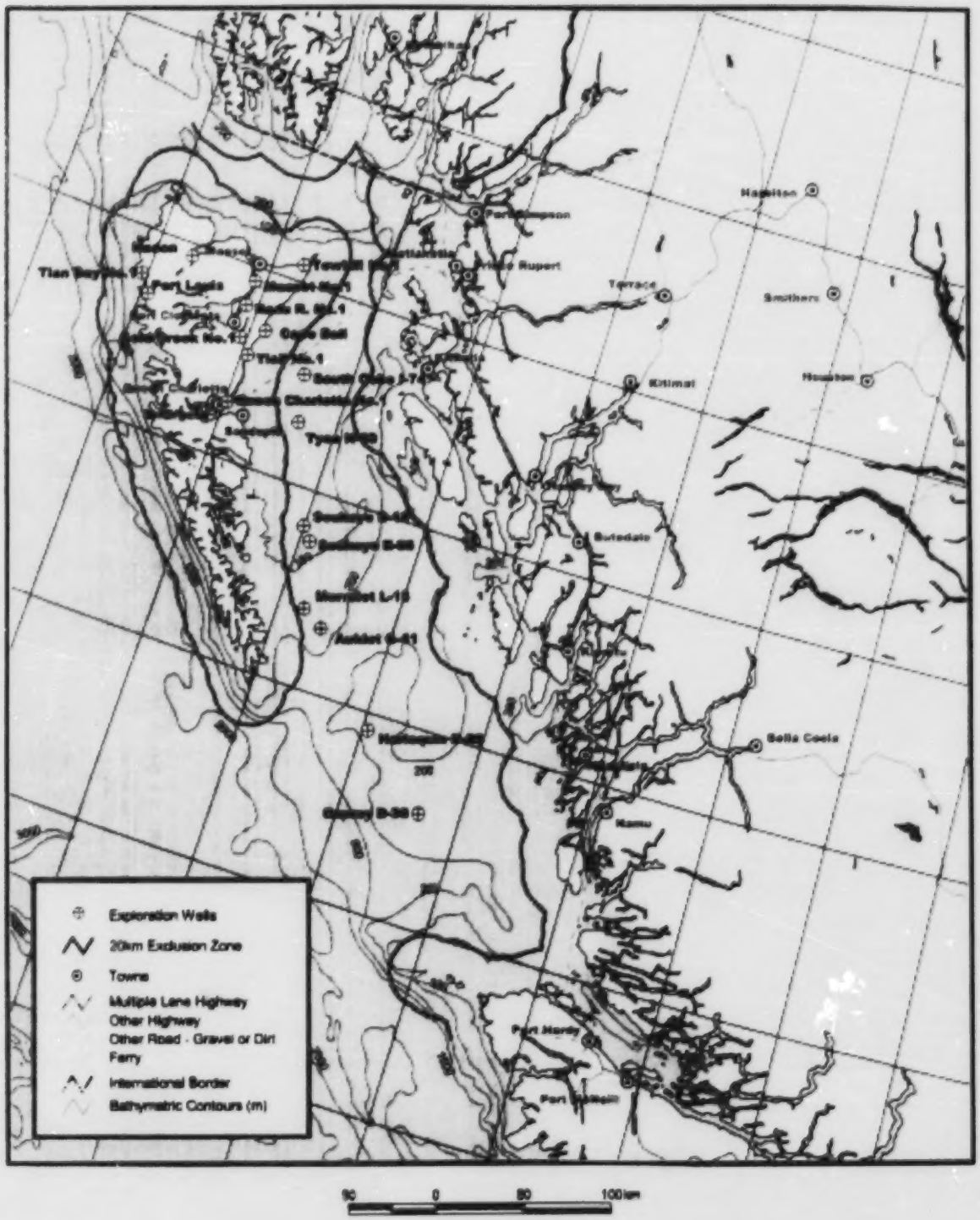
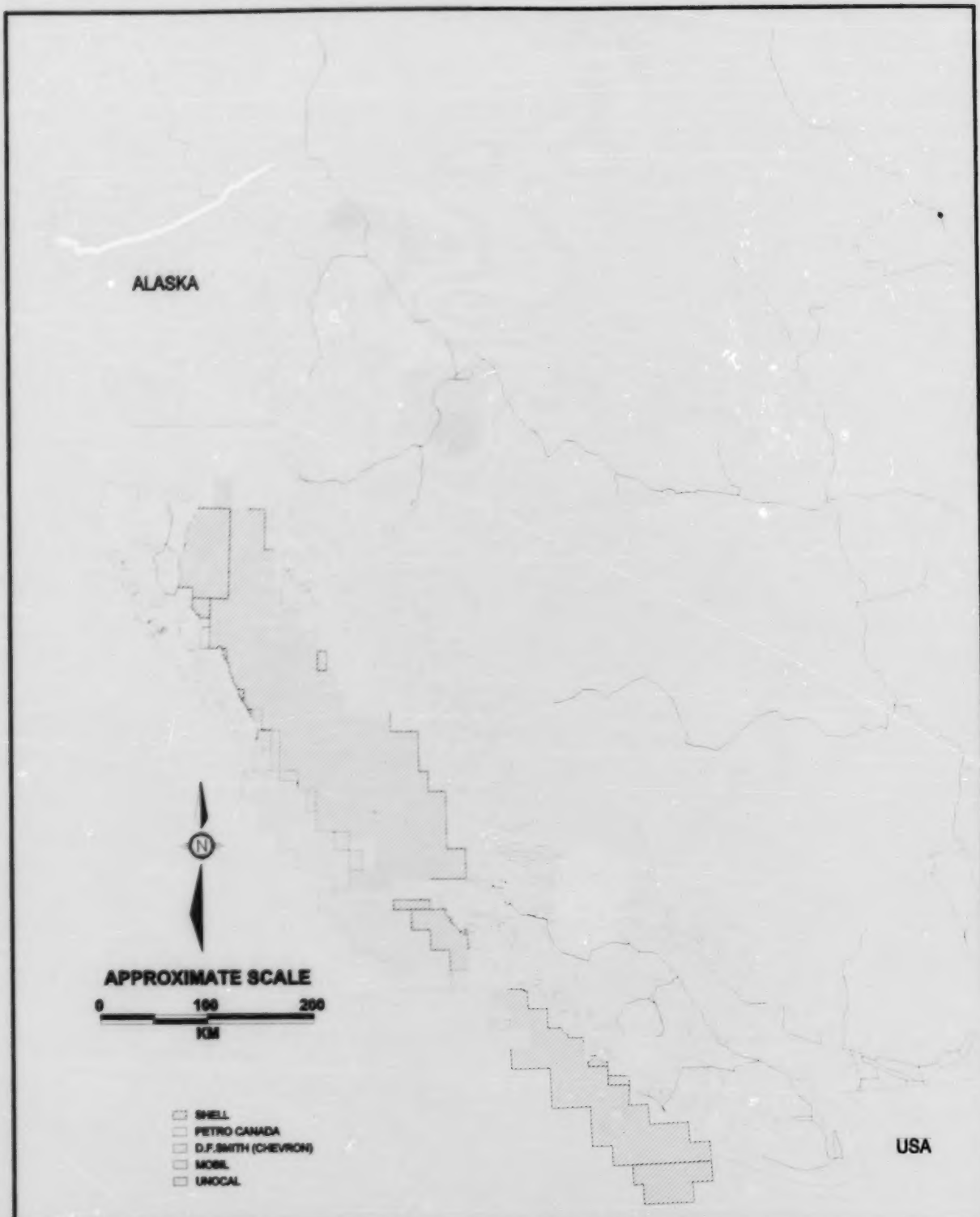


Figure 1.1 Exploration Well Locations



NORTH COAST OFFSHORE BRITISH COLUMBIA OIL & GAS TENURES

OFFSHORE OIL AND GAS TECHNOLOGY UPDATE

BC MINISTRY OF ENERGY AND MINES

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Jacques Whitford

- *planning and countermeasures, and*
- *compensation and managing for environmental protection.*

On the basis of the report and its recommendations, both the provincial and federal governments decided to negotiate a Pacific Accord, which would have allowed the lifting of the moratorium. However, spills from a tanker and *a tug in 1989* (Exxon Valdez and Nestucca barge) *and the subsequent public reaction to these events persuaded the two governments to continue an indefinite extension to the moratorium with no mechanism for its review.*

1.1 Canadian Offshore Oil and Gas Production in a Global Context

Canada is the third largest producer of natural gas and the 13th largest producer of crude oil in the world. In 2000, Canada produced 2.2 million barrels per day of crude oil and 6.3 trillion cubic feet of natural gas per year (CAPP 2001).

While Canada has long been producing oil and gas from on-land developments, it is a very recent participant in offshore oil and gas production. On the East Coast, one development has been decommissioned (Cohasett-Panuke, NS). There are two producing fields on the East Coast (Hibernia oil field, NF and Sable gas field, NS), one nearing development (Terra Nova, NF), one nearing the end of the regulatory approvals process (White Rose, NF) and several in the exploration stages and early stages of the regulatory approvals process. On the West Coast, the Province of British Columbia imposed a moratorium on exploration drilling in the coastal waters between Vancouver Island and Alaska in 1959. The moratorium was temporarily lifted between 1966 and 1972, during which a total of 14 exploratory wells were drilled, and it remains in effect today.

To put Canadian offshore oil and gas development in context, the following provides a brief overview of the state of offshore oil and gas development in other select jurisdictions worldwide:

- Pacific Outer Continental Shelf Region – there are currently 24 oil and gas production facilities (operated by six companies) in federal waters off the coast of California, and with one exception, all are still in operation. As of April 2001, these facilities have produced over 1 billion barrels of oil and 1.2 trillion cubic feet of gas (MMS Pacific OCS Region web site).
- Gulf of Mexico Region – while a recent study (Pulsipher *et al.* 2001) indicated that the total number of federal water (Outer Continental Shelf) oil and gas platforms in the U.S. Gulf of Mexico would begin a slow but steady decline to 2023, in 2001 (MMS Gulf of Mexico Region web site), in the Gulf of Mexico Region there were:
  - 7,480 active leases (as of September 17, 2001),
  - 40,513 approved applications to drill (as of September 17, 2001),
  - 4,025 active platforms (as of September 17, 2001),
  - 54 wells being drilled (as of February 2001), and
  - 6,440 wells producing (as of February 2001).

- Alaska Outer Continental Shelf Region – since offshore drilling began in the Alaska Outer Continental Shelf Region in 1975, nearly 100 wells have been drilled. Of the three current development exploration activities, one exploration plan was withdrawn by the developer and one received federal approval (and is expected to begin production in late 2001). The required development and production plan for the third proposal has been recently submitted, for which the draft Environmental Impact Statement (EIS) was released from the assessment process and is expected to be finalized by the end of 2001 (MMS Alaska OCS Region web site).
- United Kingdom North Sea – natural gas first came ashore from the United Kingdom North Sea in 1967; the first oil came ashore in 1975, with 1976 the first full year of production from a United Kingdom North Sea oil field. As of the beginning of 1999, 204 offshore fields in the United Kingdom North Sea were in production, of which 109 were producing oil, 79 producing gas and 16 producing condensate. In 1998, the United Kingdom North Sea produced 132.6 million tonnes of oil and 95.6 billion cubic feet of gas (UKOOA web site).
- Norwegian Continental Shelf – as of December 2001, there were 62 offshore oil and gas fields on the Norwegian continental shelf, 45 of which are producing fields (40 in the Norwegian North Sea and five in the Norwegian Sea) and 10 have shut down. Seven of the oil and gas fields (all in the Norwegian North Sea) have been approved for development and operation but have not yet started production (Norwegian Petroleum Directorate web site).
- Australia – the Australian oil and gas industry has been operating in the marine environment for 25 years and drills over 100 wells each year (both offshore and onshore). As of 2000, 19 development wells (five in first quarter 2001), and 50 explorations wells (18 in first quarter 2001) were spudded in offshore Australia (APPEA web site).

2.0 REGULATORY REGIME

There is currently no regulatory process in place in British Columbia with the specific mandate to review and approve offshore oil or gas exploration or production activities. The Oil and Gas Commission, and the British Columbia Environmental Assessment Office are the existing provincial regulatory bodies that address oil and gas activities and environmental approval processes in the province. The Oil and Gas Commission and the BC environmental assessment process are described below. The review and approval processes for the oil and gas industry in the Atlantic provinces are also described. Numerous other pieces of provincial and federal legislation that are not within the scope of this update, such as the provincial *Waste Management Act* and the federal *Transportion of Dangerous Goods Act*, would also apply to various activities undertaken in the development and operation of an offshore oil and gas industry.

2.1 Oil and Gas Commission

The Oil and Gas Commission (OGC) is the Province of British Columbia's crown corporation responsible for regulating most aspects of the upstream oil and gas industry in the province, including

crude oil, natural gas and pipeline activities. The OGC is a relatively new body, established by enactment of the *Oil and Gas Commission Act* in June 1998. It assumes most of the oil and gas regulatory responsibilities formerly held by the Ministries of Energy and Mines, Forests, and Environment, Lands and Parks. An integral part of the OGC's regulatory responsibility evolves from the *Petroleum and Natural Gas Act* and the *Pipelines Act,* and affiliated regulations. As all oil and gas exploration and production in BC to date has been land-based, none of the OGC processes have been tailored toward work in a marine environment.

The OGC is based in Fort St. John and also has offices in Victoria and Fort Nelson. The Commission is made up of 7 branches: Commissioner's Office; Applications and Approvals; Aboriginal Relations and Land Use; Corporate Services; Compliance and Enforcement; Engineering and Geology; and Legislation, Policy and Special Projects. The OGC's mandate is to provide efficient processes for the review of applications related to the oil and gas sector (*i.e.* well and road development, geophysical exploration activity, pipeline and facilities), ensuring that decisions are made in the public interest and having regard for environmental, economic and social impacts. More specifically, the OGC's mandate is to assist development of the oil and gas industry by streamlining the applications and approval processes while maintaining provincial environmental standards. Section 3 of the *Oil and Gas Commission Act* states that the purposes of the OGC are to:

a) regulate oil and gas activities and pipelines in British Columbia in a manner that
   i) provides for the sound development of the oil and gas sector, by fostering a healthy environment, a sound economy and social well being,
   ii) conserves oil and gas resources in British Columbia,
   iii) ensures safe and efficient practices, and
   iv) assists owners of oil and gas resources to participate equitably in the production of shared pools of oil and gas;
b) provide for effective and efficient processes for the review of applications related to oil and gas activities or pipelines, and to ensure that applications that are approved are in the public interest having regard to environmental, economic and social effects;
(c) encourage the participation of First Nations and aboriginal peoples in processes affecting them;
(d) participate in planning processes; and
(e) undertake programs of education and communication in order to advance safe and efficient practices and the other purposes of the Commission.

To support the development permit application process, the OGC has developed a number of checklists to ensure proponent's applications are complete and entered into a Memorandum of Understanding (MOU) with the Treaty 8 First Nations having Traditional Territories in the Peace River basin (West Moberly, Saulteau, Prophet River, Fort Nelson, Halfway, Blueberry, Doig, and Dené Tha'). This MOU clearly outlines the approval process with respect to First Nations review of the application, process for identification of potential Treaty Rights infringement(s) and timing. In addition, approximately 60 approval application checklists have been prepared for most activities requiring approval such as: public

consultation; geophysical - crown and private land; wells - crown, private, and agricultural lease; roads; pipelines - crown and private land; powerlines; quarries; airstrips; on-lease and off-lease facilities; and others.

Applications for well, geophysical and pipeline projects must assess project effects on the environment (forest, land and habitat), First Nations and archaeology issues in the application. Further, all applications to the OGC are required to assess the need for public consultation and ensure that a consultation process commensurate with the project scope is undertaken. This consultation process must include all stakeholders potentially impacted by an application, including First Nations. The application forms for specific development (geophysical, well and pipeline) contains a section for public consultation and requires the applicant to provide a record of all consultation conducted. This includes documentation of parties consulted, means of contact, dates, notes, issues raised, how those issues were addressed and if there are any outstanding or unresolved concerns. As part of the Pre-Application review process, the OGC assesses the consultation process and the Aboriginal Affairs, Policy and Land Use Branch specifically reviews the Application and consultation with respect to potential Treaty Rights infringement for Treaty 8 First Nations.

To speed the screening process, the OGC has developed an application sorting function based on the complexity of the project. The process involves the division of applications into Simple, Normal, or Complex categories. This screening process limits application routing to only the required reviews. The streamlined review process also gives proponents a more accurate estimate of the processing time required for each application. Factors considered by the OGC for classification of an application for geophysical activities, wells and pipelines are outlined in Table 2.1. If the application is complete and all issues have been addressed to the satisfaction of the OGC, approval is granted through a single approval document.

2.2 British Columbia Environmental Assessment Process

The environmental approval process for large projects in British Columbia is regulated through the British Columbia Environmental Assessment Office (BCEAO). All projects that are considered a reviewable project pursuant to the *Reviewable Projects Regulation* of the British Columbia *Environmental Assessment Act* (*BCEAA*) must obtain an approval through the environmental assessment review process. The *BCEAA* process features a multi-staged project review. Depending on the resolution of environmental issues, the review may require up to three stages: Stage 1 – Application; Stage 2 – Project Report; Stage 3 – Public Hearing. A project may be approved after any of these stages. The test of whether a project moves to the next Stage is whether or not all environmental issues have been sufficiently resolved. To date, no review has progressed to Stage 3.

Table 2.1 OGC Applications Identification Table

	GEOPHYSICAL	WELLS	PIPELINES
SIMPLE*	**PRIVATE:** **Geophysical Program** on private land or agricultural lease that includes the following: No stream crossings to be crossed with mechanical equipment. No crown timber. All road use permits in place. *Archaeological overview assessment (pre-application) is completed with no recommendation for an Archeological Impact Assessment or application is in an accepted area of very low potential.* **CROWN:** **Geophysical Program** on crown land *Note: An application that does not require Aboriginal consultation, an "Application Pre-Assessment" form must be completed and signed off by the Director of Aboriginal Affairs and Land Use.* No cutting permit required. Existing access. Not in special management areas. No stream crossings to be crossed with mechanical equipment. All road use permits in place. No range tenures impacted or agreements already in place. Minimal public/stakeholder impact or detailed public consultation completed as outlined in the Oil and Gas Activity Public Consultation Policy and Guidelines and issues effectively mitigated.	**PRIVATE:** **Well** (and access) on private land or agricultural lease that includes the following: Sweet gas objective (i.e. Bluesky, Gething, Jean Marie formations) Land owner (leaseholder) agreement(s) submitted. *Archaeological overview assessment (pre-application) completed or application is in an accepted area of very low potential.* Minimal public/stakeholder impact or detailed public consultation completed as outlined in the Oil and Gas Activity Public Consultation Policy and Guidelines No stream crossings. No crown timber. Road use permits in place. Schedule A pre-site assessment submitted. **CROWN:** **Well** on crown land: *Note: An application that does not require Aboriginal consultation, an "Application Pre-Assessment" form must be completed and signed off by the Director of Aboriginal Affairs and Land Use.* No cutting permit required. Sweet gas objective (i.e. Bluesky, Gething, Jean Marie formations) Minimal public/stakeholder impact or detailed public consultation completed as outlined in the Oil and Gas Activity Public Consultation Policy and Guidelines and issues effectively mitigated. Not in special management areas No stream crossings. No range tenures impacted or agreements already in place. Schedule A pre-site assessment submitted. No Certificate of Restoration on existing site	**PRIVATE:** **Pipeline** on private land. Land owner agreement(s) in place. *Archaeological overview assessment (pre-application) completed or application is in an accepted area of very low potential.* No crown timber. Road use permits in place. No stream crossings **CROWN:** **Pipeline** on crown land: *Where low infringement has been identified, as reviewed and approved by Aboriginal Affairs and Land Use Policy Branch.* Within existing well site Rights of Ways or Licenses of Occupation. Wholly within an existing pipeline Right of Way with no stream crossings or no crown timber removal. Minimal public/stakeholder impact or detailed public consultation completed as outlined in the Oil and Gas Activity Public Consultation Policy and Guidelines and issues effectively mitigated.

	GEOPHYSICAL	WELLS	PIPELINES
AMENDMENTS	**Minor Amendments:** Helipads for functionality as per Ministry of Forests and WCB guidelines. *Note: An application that does not require Aboriginal consultation, an "Application Pre-Assessment" form must be completed and signed off by the Director of Aboriginal Affairs and Land Use.* Minimal public/stakeholder impact or detailed public consultation completed as outlined in the Oil and Gas Activity Public Consultation Policy and Guidelines and issues effectively mitigated. No major issues identified in review of original application. Private land with no major issues identified on original application.	Minor Amendments-Wells: addition of borrow pits, decking sites, remote sumps, workspaces, minor access changes. *Note: An application that does not require Aboriginal consultation, an "Application Pre-Assessment" form must be completed and signed off by the Director of Aboriginal Affairs and Land Use.* Minimal public/stakeholder impact or detailed public consultation completed as outlined in the Oil and Gas Activity Public Consultation Policy and Guidelines and issues effectively mitigated. No major issues identified in review of original application.	**Minor Amendments-Pipelines: addition or relocation of borrow pits or temporary workspaces.** *Note: An application that does not require Aboriginal consultation, an "Application Pre-Assessment" form must be completed and signed off by the Director of Aboriginal Affairs and Land Use.* Minimal public/stakeholder impact or detailed public consultation completed as outlined in the Oil and Gas Activity Public Consultation Policy and Guidelines and issues effectively mitigated. No major issues identified in review of original application.
NORMAL*	All applications that are not described in the simple or complex categories.	All applications that are not described in the simple or complex categories.	All applications that are not described in the simple or complex categories.
COMPLEX*	Any applications that are: Proposed in environmentally sensitive area as identified in the Land and Resource Management Plan as a Special Management Zones, adjacent to, or crossing major fish bearing streams. *Projects that are identified as having a medium or high probability of infringement on First Nation Treaty Rights. (as outlined in the MOU'S signed by the member First Nations of Treaty 8 and the Province of BC)* *Archaeological pre-impact assessment required, and not completed prior to the application submission.* Applications located outside North Eastern BC (Fort Nelson, Fort St. John, Dawson Creek) MOF Districts 3D Applications	Any applications that are: Proposed in environmentally sensitive area as identified in the Land and Resource Management Plan as a Special Management Zones, adjacent to, or crossing major fish bearing streams. Special sour wells. *Projects that are identified as having a medium or high probability of infringement on First Nation Treaty Rights. (as outlined in the MOU'S signed by the member First Nations of Treaty 8 and the Province of BC)* *Archaeological pre-impact assessment required, and not completed prior to the application submission.* Applications located outside North Eastern BC (Fort Nelson, Fort St. John, Dawson Creek) MOF Districts Well and access proposed for summer construction in traditional winter access areas	Any applications that are: Proposed in environmentally sensitive area as identified in the Land and Resource Management Plan as a Special Management Zones, adjacent to, or crossing major fish bearing streams. *Projects that are identified as having a medium or high probability of infringement on First Nation Treaty Rights. (as outlined in the MOU'S signed by the member First Nations of Treaty 8 and the Province of BC)* *Archaeological pre-impact assessment required, and not completed prior to the application submission.* Applications located outside North Eastern BC (Fort Nelson, Fort St. John, Dawson Creek) MOF Districts

* Criteria may be changed at the discretion of the Director

Another feature of *BCEAA* is specific timelines for project reviews. The schedule assumes that the BCEAO, the Project Committee, the Ministers and regulators take the maximum allowable time for each step in the review process permitted under BC*EAA*. There remains some potential, therefore, to reduce the overall duration of the regulatory approval process if the parties involved do not use their maximum allowable time to review the Application.

A Stage 1 Application to the BCEAO must contain all of the following information upon submission before it will be accepted for review:

- a description of the purpose and major components of the project;
- existing information pertaining to environmental, social, economic, cultural, heritage and health characteristics and conditions in the vicinity of the project;
- on and off site facilities associated with the project;
- the construction plan for the project and a timetable for the completion of construction;
- any new or expanded public works or undertakings that will be required because of the project;
- potential effects of the project;
- the measures that the proponent proposes in order to prevent or mitigate adverse effects;
- any relevant plans pertaining to land use and to related resource issues in the area of the project that are authorized under an enactment;
- public information distribution activities and consultation activities undertaken by the proponent and a summary of the public response and of the issues identified;
- any program of public information distribution or consultation proposed by the proponent during the next stages of project planning and review;
- information distribution activities and consultation undertaken by the proponent with a First Nation and a summary of the First Nation's response and of the issues identified;
- any program of information distribution or consultation proposed by the proponent with a First Nation during the next stages of project planning and review;
- any discussions undertaken by the proponent about the effects of the project, with ministries or agencies of the government of British Columbia, with departments or agencies of the government of Canada, with municipalities or regional districts or with British Columbia's neighbouring jurisdictions; and
- the issues identified in the discussion referred to in the previous point.

Within seven (7) days of the submission of the Application, the Executive Director screens and accepts the Application for review. Once the Application is accepted by the BCEAO, the Executive Director establishes a Project Committee to review the proposed project and provide recommendations. The Project Committee can include representatives from the following agencies:

- the government of British Columbia;
- the government of Canada;
- any municipality or regional district in the vicinity of the project or in which the project is located;

- any First Nation whose traditional territory includes the site of the project or is in the vicinity of the project; and
- any of British Columbia's neighbouring jurisdictions in the vicinity of the project.

After the Application is accepted for review, the Project Committee will specify the length of the review period of the Application (30-75 days). At the same time, the Executive Director must advertise a public notice of the proposed project, soliciting comments from the public and other agencies in the British Columbia government and the federal government within the review time frame of the Project Committee. In addition, a copy of the Application is placed on the Project Registry for referral purposes.

The Project Committee provides comments and recommendations regarding the Application and the comments received from the public within 40 days of the completion of the Application review period. Upon the receipt and review of the Project Committee's recommendations, the Executive Director will either request a Stage 2 review of the proposed project (a Project Report), or will forward the Application and Project Committee comments to the ministers for a decision, to be made within 30 days. Once the Application is approved by the ministers, a project approval certificate is issued and the project may proceed.

2.2.1 Concurrent Regulatory Approvals

At any time after the acceptance of the Application for review by the Executive Director and the Project Committee, the proponent may request that concurrent consideration be given to the approval of permits and licenses directly related to the proposed project. The proponent must submit a formal notice to the Executive Director requesting that applications for licenses and permits be reviewed concurrently with the Application.

Concurrent regulatory approvals could lead to expeditious approvals on proposed projects. Where a proponent requests concurrent review of other approvals, the Project Committee coordinates this review with the review of the Application. The appropriate regulatory agencies will proceed with processing the applications for specified licenses and permits related to the proposed project, following their normal procedures. However, this processing must be completed within the specified review period for the Application. The specific permits requested, if approved, will be issued with 30 days of BC*EAA* certification.

Applications for permits and licenses may need to incorporate detailed, and possibly final, engineering design information. The ability to process concurrent approvals will depend upon the proponent providing the necessary information in adequate detail.

2.2.2 Public Consultation

Prior to the submission of the Application to the BCEAO, the proponent is expected to begin

consultation with the public. Consultation at the pre-Application stage should focus on initial scoping of public interests and concerns, as the proponent becomes familiar with key stakeholders who will need to be consulted on an ongoing basis. Information sessions for the public should be advertised and held during the pre-Application stage. A comprehensive public consultation program will ensure environmental issues are identified early and can be dealt with effectively in the Application.

The Application should include documentation and a summary of all public consultation activities prior to the submission of the Application. An up-to-date mailing list of all agency/public contacts and the addresses of neighbouring landowners and businesses should be included in the Application. In addition, the proponent must include a description of plans for future consultation activities and their timing during the Application review stage.

Once the Application has been submitted and accepted by the Executive Director of the BCEAO, the public must be formally notified of the availability of the Application for review. The Executive Director is required to advertise a notice of the availability of the Application and to invite public comments during the specified Application review time period. The proponent is also required to advertise a notice about the availability of the Application for comment, and to carry out any public consultation plans outlined in the Application document during the specified review period.

Following the review of the Application and the submission of comments from the public, the proponent will be provided with the comments submitted to the BCEAO and will have a brief opportunity to provide a written reply. The proponent is required to respond to the public comments in a timely manner so that the Project Committee can take these responses into consideration within the time allotted to make recommendations to the Executive Director.

In general, the costs of Application distribution, advertisement, or public consultation will be the responsibility of the proponent.

2.2.3 Federal Environmental Impact Assessment

An environmental assessment pursuant to the *Canadian Environmental Assessment Act* (*CEAA*) may be triggered if the proposed project involves the federal government in any of the following ways:

- the proponent is an agent of the federal government;
- the federal government provides funding for the proposed project;
- the proposed project requires leasing or buying land from the federal government; or
- the proposed project requires a permit or a license from a federal authority.

In the case that a federal environmental assessment is triggered, the Province of British Columbia and the federal government have negotiated a bilateral agreement to harmonize requirements for environmental assessments under both processes. The purpose of this bilateral agreement is to provide a streamlined approach to federal-provincial environmental assessments and to reduce costly delays in

project approval and repetition of environmental assessment information submitted to regulatory agencies. In order to achieve this "one project - one assessment" objective, federal agencies will designate the process of screening or comprehensive study under the *Canadian Environmental Assessment Act* to the provincial Environmental Assessment Office. At the conclusion of the environmental assessment, both governments will make their respective decisions. In this manner, each government retains its decision-making role, but the two decisions are made on the basis of information gathered and analyzed through a single process.

2.3 Atlantic Canada

The approvals process for offshore oil and gas exploration in Atlantic Canada is regulated through the Canada-Nova Scotia Offshore Petroleum Board (C-NSOPB), the Canada-Newfoundland Offshore Petroleum Board (C-NOPB), the National Energy Board (NEB), and/or provisions of the *Canadian Environmental Assessment Act*. Development in most of offshore Nova Scotia is subject to the provisions of the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act* and the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation (Nova Scotia) Act* (the Accord Acts). Development in offshore Newfoundland is subject to the provisions of the *Canada-Newfoundland Atlantic Accord Implementation Act* and the *Canada-Newfoundland Atlantic Accord Implementation (Newfoundland) Act* (the Accord Acts). The Acts and their regulations and guidelines are found on the C-NSOPB and C-NOPB websites. The information in this section is from the Acts and their regulations and the Nova Scotia and Newfoundland reports in The Regulatory Roadmaps Projects compiled by the Atlantic Canada Petroleum Institute (ACPI) (ACPI and Erlandson & Associates 2001a; 2001b) and from the recently completed White Rose Oilfield Comprehensive Study (Husky Oil 2000).

2.3.1 Roles of the Boards

The C-NSOPB and C-NOPB are independent joint agencies representing the Government of Canada and the Governments of Nova Scotia and Newfoundland and Labrador, respectively, and are responsible for management of the hydrocarbon resources (including regulation and safe practices) in the Nova Scotia and Newfoundland offshore areas pursuant to the Accords Acts. The C-NSOPB was established in 1987; the C-NOPB in 1985. In carrying out their mandates, the Boards operate autonomously in making their decisions, other than those described in the Accords Acts as "fundamental decisions", which are subject to the approval of the federal and provincial energy ministers. The Boards continuously monitor the activities of offshore operators in the areas of safety, environmental protection, resource management, and industrial benefits (as per the provisions of the Accord Acts as they relate to providing full and fair opportunity to workers and companies in Canada, and particularly in Nova Scotia and Newfoundland and Labrador, to participate in the supply of goods and services used in the offshore activity).

The C-NSOPB's principal responsibilities include (C-NSOPB website):

- ensuring the safe conduct of offshore operations;

- protection of the environment during offshore petroleum activities;
- management of offshore oil and gas resources;
- review of industrial benefits and employment opportunities;
- issuance of licenses for offshore exploration and development; and
- resource evaluation, data collection and distribution.

The C-NOPB's responsibilities include (C-NOPB website):

- the sale of interest in lands;
- the issuing of exploration licenses;
- approvals and authorizations pertaining to exploration activities;
- the declaration of Significant and Commercial discoveries;
- the issuing of production licenses;
- decisions relating to the commencement, continuation, and suspension of drilling and production;
- the administration of regulations; and
- the exercise of emergency powers pertaining to safety, environmental protection, and resource conservation.

In fulfilling these roles, the C-NSOPB/C-NOPB will often place conditions upon a development as they relate to environmental protection (requiring an environmental protection plan for each phase of a project), environmental monitoring (conducting environmental effects monitoring to validate the potential effects predictions made in environmental assessment reports), and worker safety (requirements for safety plans, conducting concept safety analyses). In addition to placing conditions on planning processes, the C-NSOPB/C-NOPB will also often require commitments/place conditions upon the design of the project (e.g., requiring specific safety design considerations be included, such as double-hulled vessels for operating in waters with pack ice and icebergs).

The C-NSOPN/C-NOPB also provide regulatory advice/direction on guidelines, such as the Offshore Chemical Selection Guidelines or the Offshore Waste Treatment Guidelines. These latter guidelines, developed in 1996 by both the C-NSOPB and C-NOPB in conjunction with the National Energy Board (NEB), are currently under review and the two provincial Boards enforcement of these Guidelines can vary. For example, an important issue is the disposal of drill cuttings (refer to Section 6.1.3.1), and whether or not they can be discharged over the side. The current (1996) Offshore Waste Treatment Guidelines sets a 15 percent retention of oil on cuttings (15 g/100 g or less of dry solids) for treated drill cuttings disposed over the side. The C-NSOPB currently holds with the North Sea model of allowing 1 percent oil retained on cuttings for drill cuttings to be disposed over the side (this limit has been in effect since January 1, 2000 (C-NSOPB Policy on Discharge of Oil-Based Muds)). As this limit is not possible to meet under current best available technology, developments must re-inject cuttings back into the field, or ship cuttings to shore for approved disposal. The C-NSOPB has recently allowed exemptions to the 1 percent limit for several exploration drilling projects to the USEPA limit of 6.9

percent wet weight on cuttings if the proponent accomplishes it using a demonstration technology. The C-NOPB, while currently allowing over the side discharge at the 15 percent limit (they issued an Amendment to the Offshore Waste Treatment Guidelines on the "Use of Synthetic Based Drilling Mud in the Offshore Newfoundland Area"), is reviewing reducing the limit to 8 percent, which is theoretically possible with best available technology.

2.3.2 Development Application Process

2.3.2.1 Project Approval

The Accord Acts are very similar, as are the development regulations, approvals and authorizations. Both Accord Acts will be discussed in tandem, with any significant differences indicated.

The Accord Acts require that prior to production from a pool or field, the operator of the pool or field must hold a valid production license and that an approved Development Plan be in place. Approval of the Development Plan includes consideration of matters relating to the safety of operations, protection of the environment, and conservation of the petroleum resource. Approval of a Canada-Nova Scotia Industrial Benefits and Employment Plan or Canada-Newfoundland Benefits Plan (Benefits Plans) is a statutory pre-condition to approval of the Development Plan.

Proponents who wish to develop a field in the Nova Scotia/Newfoundland offshore area make the C-NSOPB/C-NOPB aware of their intentions as early as possible by meeting with the C-NSOPB/C-NOPB to discuss the proposal. Subsequently, a proponent submits written notice and description of the proposed development to the C-NSOPB/C-NOPB. A proponent must then submit a Development Application (DA).

The following documents must be included with every DA:

- Development Plan;
- Canada-Nova Scotia Benefits Plan or Canada-Newfoundland Benefits Plan (depending on jurisdiction); and
- Development Application Summary.

The C-NSOPB/C-NOPB may also require one or more auxiliary documents including:

- Environmental Impact Statement (EIS) (including a Socio-Economic Impact Statement (SEIS)) (Nova Scotia process) or separate EIS/SEIS documents (Newfoundland process).
- Generic Safety Plan (including a Concept Safety Analysis);
- Environmental Protection Plan; and
- any other documentation deemed necessary by the C-NSOPB/C-NOPB (these are referred to as Part

II documents and contain specific geotechnical and engineering data such as reservoir modelling – these can only be released to the public with permission from the proponent due to their proprietary nature).

A Development Plan provides the C-NSOPB/C-NOPB with a description of all phases of the proposed offshore hydrocarbon development process associated with the proposed project. It also provides sufficient information to enable the C-NSOPB/C-NOPB to conduct a public review of the proposed project activities, if it deems such a review to be necessary.

A Development Plan outlines the work that is to be done during all subsequent phases of the project, and the procedures that will be used in completing this work. Work Authorizations associated with the construction, installation and commissioning, production and abandonment phases of a project will not be granted until the applicant's Development Plan has received approval from the C-NSOPB/C-NOPB. The DA and its supporting documentation is also reviewed by the appropriate federal and provincial agencies.

Once the C-NSOPB/C-NOPB completes an adequacy review of the DA (and reviews any required DA Supplemental Report), the DA is provided to a Public Review Commission (or panel). The Commission reviews the DA and holds a public review of the DA and may request additional information based on Commission review and comments received from public. The Additional Information Document is also reviewed by the Commission and made available to the public. The Commission then posts a Public Notice of Agenda of Public Hearings, 30 days in advance of initiating public hearings (which can last one to three weeks). At the completion of the hearings, the Commission prepares a Recommendation Report to C-NSOPB/C-NOPB, which in turn prepares a Decision Report (which will include both the Commission's recommendations and the C-NSOPB's/C-NOPB's Conditions of Approval).

2.3.2.2 Development Approval

Once the C-NSOPB/C-NOPB has fulfilled their role in the project approvals process, their primary mandate is to oversee the operation and safety of the developments. There are several Regulations and Guidelines which oversee the way a development proceeds, including:

- *Nova Scotia Offshore Area Petroleum Geophysical Operation Regulations/Newfoundland Offshore Area Petroleum Geophysical Operations Regulations*;
- *Nova Scotia Certificate of Fitness Regulations/Newfoundland Offshore Certificate of Fitness Regulations*;
- *Nova Scotia Offshore Area Petroleum Diving Regulations/Newfoundland Offshore Area Petroleum Diving Regulations*;
- *Nova Scotia Offshore Area Petroleum Production and Conservation Regulations/Newfoundland Offshore Area Petroleum Production and Conservation Regulations*;
- *Nova Scotia Offshore Petroleum Drilling Regulations/Newfoundland Offshore Petroleum Drilling*

Regulations;

- *Nova Scotia Offshore Petroleum Installations Regulations/Newfoundland Offshore Petroleum Installations Regulations*;
- *Regulations Respecting Oil and Gas Operations in the Nova Scotia Offshore Area/Newfoundland Offshore Area Oil and Gas Operations Regulations*;
- *Canada-Nova Scotia Oil and Gas Spills and Debris Liability Requirements Regulations/Canada-Newfoundland Oil and Gas Spills and Debris Liability Regulations*;
- *Newfoundland Offshore Area Registration Regulations* (Newfoundland only);
- *Hibernia Offshore Development Project Offshore Applications Regulations* (Newfoundland only);
- *Hibernia Development Project Act* (Newfoundland only);
- Guidelines Respecting Drilling Programs in the Nova Scotia Offshore Area/Guidelines Respecting Drilling Programs in the Newfoundland Offshore Area;
- Guidelines Respecting Financial Responsibility Requirements for Work or Activity in the Newfoundland and Nova Scotia Offshore areas;
- Offshore Chemical selection Guidelines;
- CNSOPB/CNOPB Joint Guideline-Data Acquisition and Reporting for Well, Pool and Field Evaluations;
- Offshore Waste Treatment Guidelines (joint C-NOPB/C-NSOPB and NEB 1996 report, currently under review);
- Guidelines for Plans and Authorizations Required for Development Projects (C-NSOPB)/Development Application Guidelines (C-NOPB);
- Operator's Safety Plan (C-NSOPB)/Safety Plan Guidelines (C-NOPB);
- Geophysical and Geological Programs in the Nova Scotia Offshore Area-Guidelines for Work Programs, Authorizations and Reports/Geophysical, Geological, Environmental and Geotechnical Program Guidelines (C-NOPB);
- Industrial Benefits and Employment Plan - Nova Scotia Offshore Area (C-NSOPB);
- Respecting Physical Environment Programs during Petroleum Drilling and Production Activities on Frontier Lands (C-NSOPB);
- Issuance of Exploration Licenses (C-NSOPB);
- Guidelines Respecting Monthly Production Reporting for Producing Fields in the Newfoundland Offshore Area (C-NOPB);
- The Newfoundland Offshore Area Registration System Guidelines (C-NOPB);
- Newfoundland Offshore Area Guidelines for Drilling Equipment (C-NOPB); and
- Field Evaluations in the Newfoundland Offshore Area (C-NOPB).

Offshore development also requires the following approvals from the C-NSOPB/C-NOPB:

- Geotechnical/Engineering/Environmental Program Authorization;
- Declaration of Commercial Discovery;

- Production License;
- Operating License;
- Authorization to Install Production Installation;
- Drilling Program Authorization;
- Certificate of Fitness issued by a Certifying Authority and required by the
  - drilling unit prior to the issuance of a Drilling Program Authorization,
  - diving program prior to the issuance of a Diving Program Authorization,
  - production facility prior to the issuance of a Production Operations Authorization;
- Approval to Drill a Well;
- Production Operations Authorization;
- Diving Program Authorization; and
- Abandonment Program Authorization.

An offshore development would also be required to provide monthly accident statistics and well termination records, and applications for any variance from issued permits.

Other applicable regulations include the *Petroleum Occupational Safety and Health Regulations* (NS, Draft 1990)/Draft *Newfoundland Petroleum Occupational Safety and Health (OSH) Regulations* and the *Canada Oil and Gas Operations Regulation.*

2.3.3 Joint Offshore Board/Canadian Environmental Assessment Act Process

2.3.3.1 Project Approval

The development of offshore oil and gas projects is subject to the *Canadian Environmental Assessment Act* (*CEAA*).

Responsible Authorities

C-NSOPB/C-NOPB

In Atlantic Canada, the C-NOPB must issue a production license respecting the project, and thereby performs a duty relating to "the administration of federal lands and...disposes of those lands or any interest in those land...for the purpose of enabling the project to be carried out" within the meaning of paragraph 5(1)(c) of *CEAA*. The C-NOPB, therefore, requires an environmental assessment under *CEAA*, and is a "Responsible Authority" respecting the project. It is not clear whether the land trigger applies under C-NSOPB's jurisdiction. In the absence of a Board which represents the federal and provincial government, it is most likely that the NEB would act as Lead Responsible Authority (an application to construct and operate a pipeline under Section 52 of the *National Energy Board Act* is a trigger under *CEAA*), given the likelihood that pipelines would be constructed to transport gas from the offshore.

Department of Fisheries and Oceans

If a proposed project is determined by DFO to result in the harmful alteration, disruption or destruction (HADD) of fish habitat, an Authorization for Works or Undertakings Affecting Fish Habitat under Section 35(2) of the *Fisheries Act* is required. As Section 35(2) authorization is a Law List trigger under *CEAA*, DFO will also be a Responsible Authority with respect to the environmental assessment of the project. Further, as a condition of this authorization, a developer is required to develop a fish habitat compensation plan that will be used by DFO in the development of a compensation agreement to compensate for losses of productive fish habitat in accordance with DFO's Policy for the Management of Fish Habitat. Given the importance DFO places on HADD and compensating for a HADD determination, a brief overview of the HADD compensation process is provided in Appendix 2.

Environment Canada

Environment Canada determined both for Terra Nova and White Rose projects that the construction of glory holes during the project and the deposition of spoils upon the surrounding seabed likely will require a Disposal at Sea Permit under the *Canadian Environmental Protection Act*, and that Environment Canada is a Responsible Authority. If an offshore development intends to use glory holes, or is burying/trenching pipelines, Environment Canada would be a Responsibility Authority.

Industry Canada

Industry Canada has determined for White Rose that the radio equipment on the production installation will require its approval pursuant to Section 5(1)(f) on the *Radiocommunications Act*, and that it, therefore, is also a Responsible Authority respecting the proposed project. It is very likely that Industry Canada will be a Responsible Authority for any offshore development that conducts radio communication.

DFO-Canadian Coast Guard

An approval may be required under the *Navigable Waters Protection Act* (*NWPA*) (DFO-Canadian Coast Guard) in cases where proposed development activities have the potential to interfere with navigable waters (this is usually limited to 12 nautical miles from shore). In the event there is a nearshore/onshore section of pipeline, there would be a trigger under the *NWPA*, and therefore, DFO-Canadian Coast Guard would also be a Responsible Authority.

Process

Offshore development falls within the *Comprehensive Study List Regulations*, Part IV, Oil and Gas Projects, Section 11. The lead Responsible Authority is designated from among the Responsible Authorities, and is responsible for coordinating the government and public review.

The submission of a project description document serves the purpose of project referral to federal authorities pursuant to *CEAA*. Because of the regulatory overlap between the Accord Acts and *CEAA*

with respect to environmental protection, the respective processes may be harmonized with respect to fulfilling information requirements of both processes (or three, if the NEB is involved, as is the case if a development includes the construction and operation of a pipeline).

The review of a Comprehensive Study can be conducted concurrently or in advance of the DA (as was the case with the White Rose DA) (However, the Commission's Notice of Agenda for Public Hearings (see Section 2.2.2.1) cannot be published until the federal Minister of Environment has released the project from *CEAA*).

2.3.3.2 Development Approval

Prior to the construction and operation of a development, other federal authorizations, permits and licenses must be acquired exclusive of release from *CEAA*. The primary approvals are:

- HADD Authorization (note that HADD must be quantified and a Habitat Compensation Strategy provided to DFO prior to release from *CEAA*) – the HADD Authorization can be negotiated with DFO concurrently with the DA Approval process (in anticipation of release from the DA process and approval to proceed with the project), but must be in place prior to any disturbance of the substrate (see Appendix 2);
- Ocean Disposal Permit – an Ocean Disposal/Disposal at Sea Permit application can be forwarded to Environment Canada concurrently with the DA Approval process (in anticipation of release from the DA process and approval to proceed with the project), but must be in place prior to an displacement of the substrate; and
- Radio License – a Radio License application can be forwarded to Industry Canada once approval to proceed with the project is provided, but prior to the installation of the production facility.

2.3.4 Joint National Energy Board/*Canadian Environmental Assessment Act*/Board Process

2.3.4.1 Project Approval

If a pipeline (>40 km) is required, then *CEAA* is triggered by the application for a Certificate of Public Convenience and Necessity (currently, only Nova Scotia has export pipelines from offshore gas developments). In that case, the NEB would act as a Responsible Authority and provide input into the issues scoping package, provide comment on a filed Comprehensive Study and sign-off on a Comprehensive Study Report (which may be delegated to the proponent to prepare). Any public hearings (NEB requires public hearings for pipelines >40 km in length) could be coordinated between the NEB and the C-NSOPB or other Board.

The Responsible Authorities, which sign-off on the Comprehensive Study, must respond to any recommendations made by the Public Hearings Commission, with the approval of the Governor in Council (GIC). If the Comprehensive Study, and therefore, the application for a Certificate of Public

Convenience and Necessity, is released from *CEAA*, the application would then complete the NEB regulatory process, as described in Section 2.1.

2.3.4.2 Development Approval

Once the pipeline has been approved and undergone the required testing, the proponent must file an application for leave to open the pipeline from the NEB.

2.3.5 Other Approval Processes

2.3.5.1 Nova Scotia Utility and Review Board Approval Process

The construction and operation of a pipeline on Nova Scotia lands (which includes the offshore) requires authorization from the Nova Scotia Utility and Review Board (NSUARB) (ACPI and Erlandson & Associates 2001a), pursuant to the *Pipeline Act*. Specifically:

- permits to construct a pipeline; and
- license to operate a pipeline.

NSUARB only gets involved with onshore and offshore pipeline permitting that is not NEB regulated (*i.e.*, liquid lines that are not tied into a NEB-regulated transmission system (e.g., Maritimes and Northeast Pipeline) or do not otherwise cross inter-provincial boundaries).

2.3.5.2 Other Nova Scotia Regulatory Agencies

Several provincial regulatory agencies have signed Memoranda of Understanding (MOU) with the C-NSOPB, which allows these agencies the ability to address issues arising from overlapping jurisdictions. These include (ACPI and Erlandson & Associates 2001a) the:

- Nova Scotia Department of Environment and Labour;
- Nova Scotia Department of Natural Resources; and
- Energy Resources Conservation Board.

The Nova Scotia Petroleum Directorate has direct responsibility for administering the offshore royalty regime and is directly involved with providing the C-NSOPB with advice on a number of issues, including benefits. It also has MOU with other provincial regulatory agencies and provides a one-window process as the primary means of promoting consultation and communication among the agencies (ACPI and Erlandson & Associates 2001a).

The Nova Scotia Department of Fisheries and Aquaculture is a member of the C-NSOPB Fisheries and Environmental Advisory Committee. The Office of Aboriginal Affairs in Nova Scotia does not exercise regulatory functions in offshore Nova Scotia; however, it is currently in discussions which might affect

offshore oil and gas development as a result of recent court cases initiated by aboriginal communities (ACPI and Erlandson & Associates 2001a).

2.3.5.3 Other Newfoundland Regulatory Agencies

The Newfoundland and Labrador Department of Mines and Energy enacts legislation and regulations similar to the Newfoundland Accord Acts for offshore areas. In conjunction with the federal Minister of Natural Resources, the Minister of Mines and Energy is responsible for issuing directives to the C-NOPB and reviewing fundamental decisions issued by the C-NOPB (ACPI and Erlandson & Associates 2001b).

Several provincial regulatory agencies have signed MOU with the C-NOPB, which allows these agencies the ability to address issues arising from overlapping jurisdictions. These include (ACPI and Erlandson & Associates 2001b) the:

- Newfoundland and Labrador Department of Environment (recognized as the principal advisor to the C-NOPB);
- Newfoundland and Labrador Department of Labour; and
- Newfoundland and Labrador Department of Fisheries and Aquaculture.

2.3.5.4 Shore-based Facilities

It should be noted that if any shore-based facilities need to be constructed specifically for an offshore project, then those facilities may also be subject to *CEAA* and/or the relevant provincial authority. It is assumed that the potential effects of construction and operation of shore-based facilities would be assessed under the British Columbia *Environmental Assessment Act* (refer to Section 2.2).

2.3.6 Lessons Learned

Based on the recent experience with the White Rose development (and previous environmental assessments), the following are key lessons learned about the Atlantic Canada regulatory process:

- the Comprehensive Study required by *CEAA* can fulfill the EIS/SEIS requirements of the C-NSOPB/C-NOPB;
- the release of the project from *CEAA* triggers the public review under the Accord Acts (*i.e.,* the Notice of Agenda for the public hearings may not be made public until the federal Minister of Environment has released the Comprehensive Study from *CEAA*);
- liaison with stakeholders is key to the success of the project, including
  - early meetings with regulators to identify key issues, and
  - early public meetings (prior to the formal process) to both provide information to communities and stakeholders and to solicit comments and issues of concern;
- upon delivery of the environmental assessment document, a meeting for all regulators is advised to

present findings to assist regulators in their review of the document and provide clarification of any aspects of the environmental assessment; and

- early clarification of the internal regulatory review process due to harmonized nature of the various approvals processes is essential.

3.0 REGIONAL SETTING

The experience of the US Minerals Management Service (MMS) and other non-petroleum industries (such as the Voisey's Bay Nickel Company Limited Mine/Mill EIS) indicates that traditional First Nations knowledge of the biological resources of an area should be incorporated into any formal assessment of a project. The process of gathering the information should be a formalized agreement with the First Nations communities.

3.1 Marine Coastal Biodiversity/Continental Shelf Biota

3.1.1 Ecosystems

The report and recommendations of the 1986 West Coast Offshore Exploration Environmental Assessment Panel describes the biophysical environment within the region of interest. The majority of this information remains valid in terms of overall ecosystems, species, and fisheries. Some changes have occurred, however, primarily related to species stocks and harvesting operations.

The two major marine ecosystems in BC are the nearshore and continental shelf ecosystems. The main factor influencing the differences in these two ecosystems is depth. Where the nearshore ecosystem occurs in shallow waters near rocky shores, estuaries, mud flats and shallow bays, the continental shelf exists in deeper waters off shore. Because the nearshore waters are shallow, light penetrates the water, allowing vegetation such as kelp and algae to grow and become the primary producers in the ecosystem. In the continental shelf ecosystem, phytoplankton is the primary producer.

A significant feature of the continental shelf ecosystem in BC is the deep-water sponge reefs. These sponge reefs are the only known Hexactinellid sponge reefs living in the world today. They cover approximately 1,000 km^2 between the Queen Charlotte Islands and the mainland and are believed to be nearly 10,000 years old (GSC 2001). Evidence of damage to these reefs by trawling gear has created concern for the protection of these reefs.

3.1.2 Finfish and Shellfish

The stocks of many species of fish have changed since the 1986 report. Species such as Pacific halibut, petrale sole, yellowtail rockfish, *rock sole and English sole have been declining as a result of declining recruitment and Pacific hake stocks have been declining since the late 1980s, returning to historic, typical levels. Pacific cod have declined until 1996, when it experienced a slight increase to 1998 but*

was expected to decline in the subsequent two years. Rockfishes such as redstripe and redeye have increased until 1995, but abundance is expected to decline until the next major recruitment. Herring stocks have increased since 1986, but are expected to decline again in the long term (DFO 2001a; 2001b; 2001c).

Pacific invertebrate fisheries are diverse. Geoducks and intertidal clams have had quotas reduced since 1987 and the Pacific abalone fishery has been closed for most of the 1990's due to low stocks. Restrictions were placed on the BC shrimp fishery in 1997 and crab landings also declined after 1996 due to reduced stocks (BC Statistics May 2001).

Since 1986, steelhead have been re-classified as a Pacific salmon (Oncorhynchus mykiss), thus making six species of salmon caught by commercial, recreational, and aboriginal fishers in British Columbia. The other five are: sockeye, pink, chum, coho, and chinook.

Sockeye and pink salmon were once the most abundant of the Pacific salmon species. Returns of Sockeye and pink salmon were at record high levels through the 1980's and the early part of the 1990s. However, more recently, returns have decreased due to extreme fluctuations in marine survival. For example, in 1995, returns of Fraser River sockeye were well below predicted levels, even though the spawning escapement in the parent year was the highest ever recorded for this cycle.

Chum salmon catches in British Columbia appear to be highly variable and dependent on recruitment and environmental conditions.

Chinook and coho salmon are highly valued by all fishers. However, marine survival rates for the 1990s have generally been low. Some runs of chinook salmon, such as those along the west coast of Vancouver Island and some parts of the Strait of Georgia, have had severe conservation measures put in place due to protect low stock levels. Coho salmon stocks have also had low returns in the Strait of Georgia and in the upper Skeena River watershed and management measures were taken in 1995 to reduce the harvest rates on Strait of Georgia coho stocks. Since the late 1990s, there has been no commercial fishery for coho salmon. *Habitat degradation has also become a concern for Strait of Georgia coho, as human populations expand and demand for residential, commercial and recreational development increases.*

3.1.3 Seabirds

The Canadian Wildlife Service (CWS) has conducted a comprehensive inventory of colonial nesting seabird populations in British Columbia since 1986 (Rodway et al. 1988) and an overview of the historical and current information regarding seabird colony distributions and breeding populations has also been conducted (Rodway 1991). In general, over 5.6 million colonial birds are currently estimated to nest at 503 colony sites along the British Columbia coast (Rodway 1991). Most populations breed in high-density colonies which may contain various seabird species. In addition to the work being done by

the CWS, the United States Fish and Wildlife Service (USFWS) has a seabird colony database and the United States Geographic Service (USGS) have a Pacific Seabird Monitoring database. The Pacific Seabird Monitoring database includes colonies in British Columbia, however, at this time, it consists mostly of raw observations and is therefore not available to the public.

Fifteen species of seabirds are known to breed on the coast of British Columbia (Table 3.1).

Table 3.1 Status of Seabird in British Columbia and their Distribution

Species	Estimated Numbers	Status	Distribution
Fork-tailed Storm Petrel (Oceanodroma furcata)	400,000	Trends unknown, believed healthy	*Colonies on the Storm Islands in Queen Charlotte Strait and on Gillam Islands on the west coast of Vancouver Island support approximately 49 percent of the total provincial population.*
Leach's Storm Petrel (Oceanodroma leucorhoa)	1,400,000	Trends unknown; believed healthy	*A cluster of four colonies in Queen Charlotte Strait, plus two colonies on the west coast of Vancouver Island contain approximately 74 percent of the total population found an British Columbia's coast.*
Double-crested Cormorant (Phalacrocorax auritus)	4,000	Blue-listed	*Generally confined to the Strait of Georgia where numbers have increased dramatically since they were first recorded. Estimates in 1991 gave a total of over 2,000 nesting pairs in the Strait of Georgia area.*
Brandt's Cormorant (Phalacrocorax pencillatus)	200	Red-listed	*Nesting in small numbers on Sea-lion Rocks off the mid-west coast of Vancouver Island, the maximum numbers recorded up to 1991 was 150 nesting pairs in 1970.*
Pelagic Cormorant (Phalacrocorax pelagicus)	9,000	*pelagicus* subspecies red-listed; other subspecies stable	*Although they breed along the entire coastline, most of the nesting population occurs in the south on the east and west sides of Vancouver Island. An estimated 4,495 pairs were breeding at 85 sites in 1991, with 52 percent of the population nesting in the Strait of Georgia and 26 percent along the west coast of Vancouver Island.*
Glaucous-winged Gull (Larus glaucenscens)	58,000	Increasing	*These gulls have a similar distribution to that of pelagic cormorants. It was estimated that 28,953 pairs bred along the coast in 1991, with 48 percent of the total population nesting in the Strait of Georgia and 25 percent on the west coast of Vancouver Island. Data suggests that populations increased by as much as 30 percent in the Queen Charlotte Islands and by 48 percent along the northern mainland coast from 1975-1988.*

Species	Estimated Numbers	Status	Distribution
Common Murre (Uria aalge)	9,000	Red-listed	*The colony at Triangle Island is thought to support 95 percent of the breeding population (4,100 pairs in 1989).*
Thick-billed Murre (Uria lomvia),	20	Red-listed	*Known to breed on Triangle Island, which is the southern most known breeding site in the eastern Pacific.*
Pigeon Guillemot (Cepphus columba)	9,000	Trends unknown	*The most ubiquitous breeding alcid in the province, nesting at an estimated 303 sites. A total of 9,345 birds were counted around colonies during the 1991 surveys.*
Marbled Murrelet (Brachyramphus marmoratus)	36,000	Threatened (COSEWIC); red-listed	*Known to inhabit Desolation Sound.*
Ancient Murrelet (Synthliboramphus antiquus),	540,000	Vulnerable (COSEWIC); blue-listed	*Generally known to breed exclusively on the Queen Charlotte Islands where estimates have been as high as 543,000 birds. These numbers were probably higher in the past as current trends in population numbers show declines and colony abandonments. In 1991, British Columbia supported approximately 74 percent of the world breeding population.*
Cassin's Auklet (Ptychoramphus aleuticus),	2,700,000	Blue-listed	*The most abundant breeding species in British Columbia, their population is estimated to be over 2.7 million nesting at 60 sites. 73 percent of the population breed at 3 sites in the Scott Island and the rest breed in the Queen Charlotte I.*
Rhinoceros Auklet (Cerorhinca monocerata)	720,000	Stable	*Over 720,000 breed in British Columbia at over 30 sites. This represented approximately 56 percent of the world breeding population in 1991. Most are found on two colonies in Queen Charlotte Strait, four colonies on the northern mainland coast and one colony in the Scott Islands*
Tufted Puffin (Fratercula cirrhata)	78,000	Blue-listed	*Over 90 percent of the 78,000 breeding in British Columbia nest in the Scott Islands. Small numbers also breed throughout the coastline.*
Horned Puffin (Fratercula corniculata)	60	Red-listed	*Their summer range appear to be expanding along the west coast of North America. They have been confirmed nesting in British Columbia only at Anthony Island at the south end of the Queen Charlotte Islands*

Source: Rodway 1991; Environment Canada 2000

3.1.4 Marine Mammals

There are 29 species of marine mammals along coastal BC (Ministry of Forests 1995). Of these 29

species, only eight are commonly seen. These include porpoises, dolphins, seals, sea lions, otter and mink (WCOEEAP 1986). There are three marine mammals on the provincial red-list, meaning they are extirpated, endangered or threatened in British Columbia. The three species on the red-list are northern right whale (*Eubalaena glacialis*), northern sea lion (*Eumetopias jubatus*) and sea otter (*Enhydra lutris*). The BC Conservation Data Centre lists 10 species of marine mammals and three populations as vulnerable: northern fur seal (*Callorhinus ursinus*), Bering Sea beaked whale (*Mesoplodon stejnegeri*), arch-beaked whale (*Meloplodon carlhubbsi*), sperm whale (*Physeter catodon*), harbour porpoise (*Phocoena phocoena*), grey whale (*Eschrichtius robustus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), blue whale (*Balenoptera musculus*), humpback whale (*Megaptera novaeangliae*) and the Northeast Pacific Resident, Northeast Pacific Offshore and West Coast Transient populations of killer whale (*Orcinus orca*) (BC CDC 2001).

Grey whales are the first great whale to be removed from the endangered species list. As populations recover, more animals are returning to their historical British Columbia range to feed on mysid shrimp.

Research initiatives, such as the Coastal Ecosystems Research Foundation (CERF), have been conducting ongoing research on whales and dolphins on the coast of BC. *Relevant research includes grey whale toxicology. Heavy metal and PCB levels in mysid shrimp populations, primary prey for grey whales, are being studied.*

The Pacific white-sided dolphin is one of the most abundant cetaceans in the North Pacific, and in recent years, it has been sighted more frequently and in larger numbers in the inshore waters of British Columbia. Humpback whales have also been gradually returning to their original habitats, including Queen Charlotte Sound.

3.2 Commercial Fishery

During the 1990s, the number of fish processing plants has declined in British Columbia. Some of this decline was due, in part, by the industry consolidation. In 1990, there were 219 provincially licensed fish processing plants. By 1999, this number had decreased 13 percent to 190. Most of the reduction in plants was focused on Vancouver Island and the Sunshine Coast, where 28 and 10 plants, respectively, were shut down during the 1990s. The one area of the province with considerable growth during the 1990s was the North Coast, which experienced a 36 percent increase in fish processing facilities (BC Statistics May 2001).

Although there was a decline in commercial landings for wild salmon during the 1990s (Section 3.2.1), the export values of BC fish increased 10 percent from $773 million in 1990 to $853 million in 1999 (BC Statistics May 2001).

3.2.1 Salmon

Landed catch by tonne for all species of salmon has continually decreased between 1986 *and* 1999.

Statistical information is not yet available for 2000 and 2001. In British Columbia, *the catch has decreased* from 103,780 tonnes in 1986 to 96,400 tonnes in 1990 to 19,900 tonnes in 1999. Landings for pink salmon decreased 66 percent between 1986 and 1999, from approximately 29,505 tonnes to approximately 10,000 tonnes. Chum landings dropped 80 percent between 1986 and 1999 (approximately 25,197 tonnes and 5,000 tonnes, respectively). Chinook landings decreased 80 percent from 5,007 tonnes in 1986 to less than 1,000 tonnes in 1999. Of the five species of Pacific salmon, sockeye landings have fluctuated the most, however, the overall trend has resulted in a 95 percent decrease between 1986 and 1991 (approximately 30,833 and 1,800 tonnes, respectively). Because of the threat to wild coho stocks, restrictions were placed on the commercial fishery in 1996 and became progressively more severe, until there were no commercial landings of coho in 1999.

As a result of the decrease in landed catch for Pacific salmon, landed values have decreased 46 percent between 1986 and 1999. Landed values for wild salmon were approximately $265 million in 1986 and fell to approximately $170 million in 1999 (BC Statistics 2000; 2001).

3.2.2 Herring

In BC, the total herring catch by tonne, including herring spawn on kelp, increased from 1986 to 1994 (16,491 to 40,902 tonnes, respectfully), but dropped significantly in the intervening five years to 29,800 tonnes in 1999. The majority of herring is caught on the North Coast and although the landed value increased despite the down turn until 1996 ($46,209,000 to $99,700,000), it declined to approximately $50,000,000 in 1999 (BC Statistics 2000; 2001).

3.2.3 Halibut

The halibut catch by tonne in British Columbia has fluctuated only slightly since 1986. In 1996, the catch was slightly above the 1986 level (5,389 and 5,431 tonnes, respectfully) (BC Statistics 2000). In 1999, the catch was 5,500 tonnes. The majority of halibut is landed on the North Coast. Its value has increased from $24,455,000 in 1986 to $39,000,000 in 1999 (BC Statistics May 2001).

3.2.4 Groundfish

Groundfish landings have fluctuated considerably during the 1990s, however, in 1999, the landed catch for groundfish was 139,000 tonnes, which is virtually the same as the 1990 catch. During the 1990s, hake was the dominant species landed, standing at 57 percent in 1990 and 67 percent in 1999. Rockfish increased slightly from 16 percent of the harvest in 1990 to 17percent in 1999. Sole and sablefish landings decreased slightly from 4 to 3 percent. Due to the declining stocks of Pacific cod, restrictions were placed on the harvest in 1992, resulting in a decline in landed catch from 5 percent in 1990 to 1 percent in 1999 (BC Statistics May 2001).

Landed value for groundfish increased from $67 million in 1990 to $100 million in 1999 (BC Statistics May 2001).

3.2.5 Shellfish

The commercial harvest of shellfish had a dramatic increase in 1992, rising from 21,500 tonnes in 1990 to 31,500 tonnes in 1992. Landings then dropped to 24,000 tonnes in 1999. This high level of fluctuation was due to the increase in wild sea urchin landings in 1992 and the introduction of quota and area restrictions, in particular on the BC shrimp trawl fishery in 1997 (BC Statistics May 2001).

The BC shellfish fishery harvests many different species of invertebrates, however, in 1999, the largest landings were for sea urchin (6,800 tonnes), shrimp and prawns (5,200 tonnes) and crab (3,900 tonnes). Both sea urchin and shrimp harvests briefly increased in the 1990s and then decreased following restrictions put in place to protect declining stocks. The harvest of crab increased at the beginning of the decade and then declined after 1996 following management restrictions and reduced stocks. Landings for wild geoducks declined over the 1990s (approximately 4,000 tonnes in 1990 to 1,500 tonnes in 1999) due to management restrictions (BC Statistics May 2001).

3.2.6 Commercial Sport Fishery

Sport fishing continues to be an important recreational activity for both residents and non-residents of British Columbia. It is the largest industry in the fisheries and aquaculture sector in BC, with a total GDP of $214 million in 1999. The sport fishing industry had been growing up until the mid-1990s. However, it is showing the effects of the uncertainty in salmon stocks and restrictions for resource conservation measures (BC Statistics June 2001).

3.2.7 Aquaculture

Farmed salmon is the primary aquaculture species in British Columbia. *Landed tonnes and value are not available from 1986* but have generally increased during the 1990's. In 1990, 15,500 tonnes of production from salmon aquaculture operations were worth $79 million. By 1990, this increased to 49,100 tonnes worth $292 million. Before 1993, the main salmon species farmed was chinook, but by 1993, Atlantic salmon had become the number one farmed species in BC (BC Statistics May 2001).

The salmon aquaculture industry has substantially reduced in size between the mid-1980's and the mid-1990's. There are presently sixteen salmon farming companies operating in British Columbia at seventy-nine locations. A provincial government moratorium on the issuance of new tenures has been in effect since 1995, although in 1996, several tenures whose applications had been pending for some time were issued. Salmon farming sites are typically less than 10 ha in size with a less than 200 hectares of aquatic Crown land presently allocated for salmon aquaculture purposes. The locations (by regional District) of existing salmon farm site tenures in British Columbia, including inactive tenures, as of 1996 are shown in Table 3.2.

Table 3.2 Distribution of Active Grow-Out Sites by Regional District

Regional District	1996
Alberni-Clayoquot	18
Comox-Strathcona	28
Mount Waddington	21
Nanaimo, Cowichan, Capital	8
Sunshine Coast & Powell River	4

Source: www.eao.gov.bc.ca/PROJECT/AQUACULT/SALMON/Report/final/vol1/V1chp2.htm

3.3 First Nations

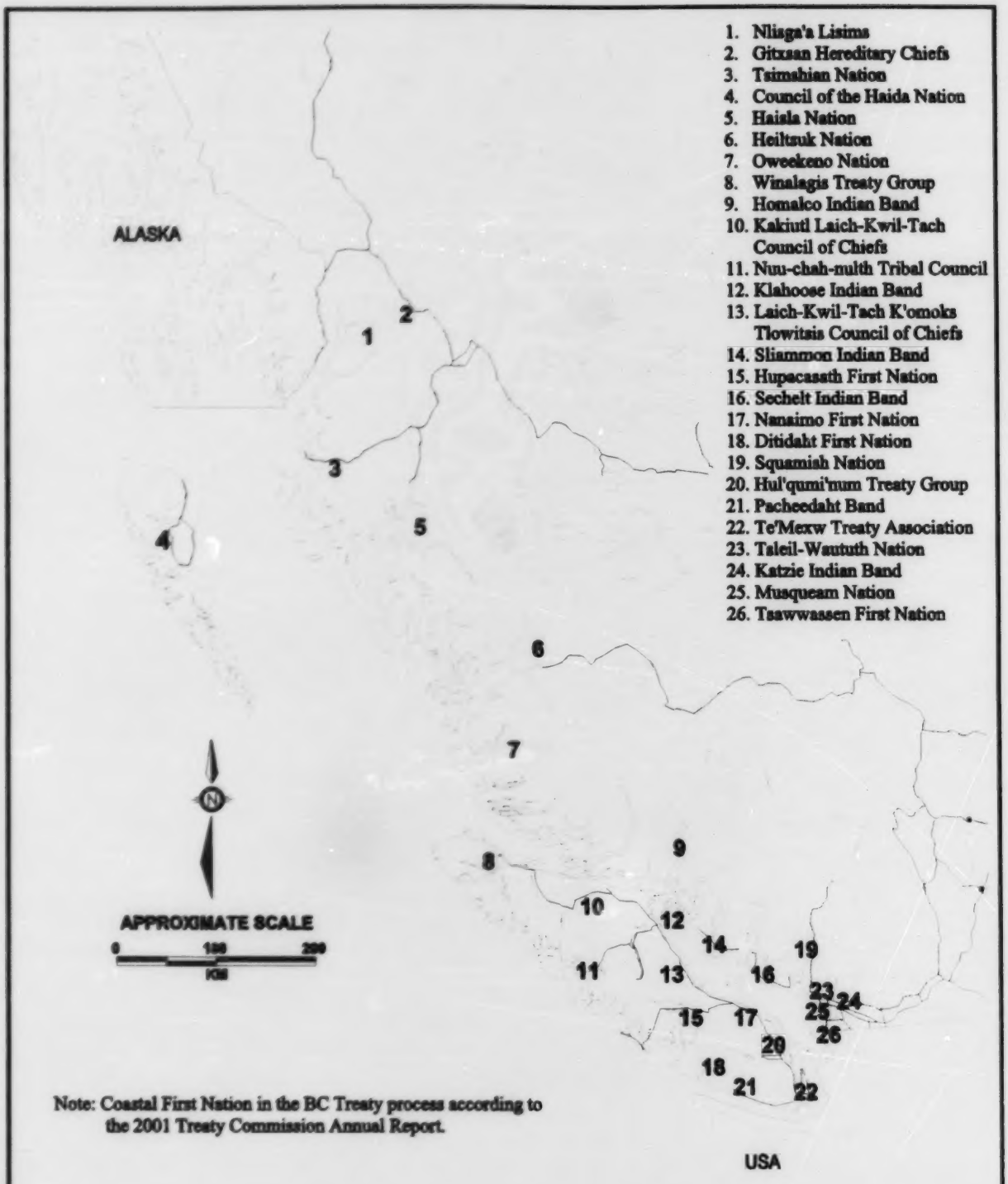
The asserted traditional territories of a number of culturally and linguistically distinct First Nations are situated on the northern Vancouver Island, central coast and north coast areas of British Columbia within the subject area under review. The Haida (the Council of Haida Nations) are situated on the Queen Charlotte Islands (Haida Gwaii) the Nisga'a (Nisga'a Lisims Government) at the mouth of the Nass River and in the Nass Valley. The Tsimishian First Nations (Tsimshian Tribal Council), Haisla Nation, and Heiltsuk First Nation are situated on the north and central coast and the Winalagalis Treaty Group, Kwaguilth First Nations on northern Vancouver Island and the south central coast. To the south of the area of review are the Nuu-chah-nulth First Nations (Nuu-chah-nulth Tribal Council) located on the west coast of Vancouver Island and the Coast Salish First Nations of the Georgia Basin watershed south of Powell River (Sliammon First Nation).

As a result of the signing of the BC Treaty Commission Agreement on September 21, 1992, tripartite negotiations are underway for most Coastal First Nations through the six stage B.C treaty process. The BC Treaty Commission's 2001 Annual Report indicates that province-wide there are 49 First Nations in 40 sets of negotiations in the treaty process. The Council of the Haida Nation is in stage 2, The Nisga'a have completed their Final Agreement and 42 First Nations are at stage 4 including the Tsimshian Nation, the Haisla Nation, the Heiltsuk Nation, the Nuu-chah-nulth Nation, and the Winalagalis Treaty Group. These latter First Nations have asserted traditional territories in the area of review. There are additional First Nations that are not participating in the treaty process that may overlap with the area of interest.

The distribution map on Figure 3.1 shows relative locations for the coastal First Nations that are currently participating in the British Columbia treaty process.

3.3.1 Populations

Population numbers for the central and north coastal First Nations communities, as of month ending September 2001, indicate that there are approximately 28,500 people affiliated with these First Nations. These statistics, from Indian and Northern Affairs Canada, British Columbia Region, include population on reserve and off reserve for each community and are presented in Table 3.3 below.



Note: Coastal First Nation in the BC Treaty process according to the 2001 Treaty Commission Annual Report.

COASTAL FIRST NATIONS IN THE BC TREATY PROCESS OFFSHORE OIL AND GAS TECHNOLOGY UPDATE BC MINISTRY OF ENERGY AND MINES	DATE: OCTOBER 19, 2001	SCALE: AS SHOWN	Jacques Whitford
	JOB No. BCV 50229	FIGURE No. 3.1	

In reviewing the population statistics by residence code presented below, the residence codes are as follows: 1 = on reserve (own band), 2 = on reserve (other band), 3 = on crown land (own band), 4 = on crown land (other band), 5 = on crown land (no band), and 6 = off reserve.

Table 3.3 Populations of Central and North Coast First Nations in the BC Treaty Process

First Nation	Affiliated Bands	Population by Residence Code						
		1	*2*	*3*	*4*	*5*	*6*	*Total*
Gitxsan Hereditary Chiefs	Gitanmaax	714	100	0	0	0	1062	1876
	Gitsegukla	490	30	0	0	0	299	819
	Gitwangak	456	29	0	0	0	507	992
	Glen Vowel/Sikokoak	153	27	0	0	0	175	355
	Kispiox	642	72	0	0	0	619	1333
Tsimshian Nation	Hartley Bay	170	12	1	0	0	447	630
	Kitasoo	320	8	0	0	0	143	471
	Kitkatla	431	18	0	0	0	1125	1574
	Kitselas	193	11	0	0	0	265	469
	Kitsumkalum	191	9	0	0	0	404	604
	Lax Kw'alaams	1076	42	0	0	1	1629	2748
	Metlakatla	105	2	0	0	0	593	700
Council of the Haida Nation	Old Massett Village Council	733	33	0	0	0	1677	2443
	Skidegate	694	6	0	0	0	542	1242
Heiltsuk Nation		1189	39	0	0	0	841	2069
Oweekeno Nation		97	12	0	0	0	126	235
Winalagalis Treaty Group	Kwakiutl	325	11	0	0	0	264	600
	Tlatlasikwala	8	8	0	0	16	14	46
	Namgis	738	28	0	0	0	724	1490
	Quatsino	211	4	0	0	0	151	366
	Gwa'Sala-Nakwaxda'xw	406	7	0	0	0	248	661
Homalco		221	6	0	0	0	191	418
Hul'qumi'num Treaty Group	Chemainus	751	65	0	0	0	209	1025
	Cowichan	1777	213	0	0	0	1565	3555
	Halalt	84	13	0	0	0	92	189
	Lake Cowichan First Nation	12	0	0	0	0	2	14
	Lyackson	12	21	0	0	0	138	171
	Penelakut	465	26	0	0	0	266	757
Pacheedaht First Nation		101	16	0	0	0	128	245
Tlowitsis Council of Chiefs		11	35	0	0	63	233	342
Totals		**12,776**	**903**	**1**	**0**	**80**	**14,679**	**28,439**

Source: INAC – BC Registered Indian Population

3.3.2 Position Statements

Significant changes have occurred since the *Report and Recommendations of the West Coast Offshore Exploration Environmental Assessment* of 1986 that have led to greater involvement of First Nations in the management of natural resources within their traditional territories. These changes include a series

of Supreme Court of Canada decisions, Guerin (1984), Sparrow (1990), and Delegamuukw (1993, 1997), creation of the British Columbia Treaty Commission Agreement in 1992, and the Nisga'a Final Agreement, now recognized under s35 of the *Constitution Act*. More recently, the Province of British Columbia has entered into two protocol agreements with many of the First Nations having traditional territories in the area of review for the offshore oil and gas moratorium. While these agreements do not address the offshore oil and gas issue they do move the signatory parties toward a greater role in natural resource management by addressing a series of process and forestry related objectives. The agreements also include mechanisms to consider and where possible to address ecological and environmental issues and other concerns and to develop a strategic land use plan with the Province.

A number of First Nations have issued formal and informal statements on the Moratorium on North Coast Oil and Gas Exploration. The Tsimshian and Haida nations issued a joint statement on the moratorium on May 14, 2001. This statement supports retention of the moratorium citing two primary reasons: "the petroleum interests...are within the territorial seas" of the two Nations; and, "the risk of harm from an accidental oil spill or allowable discharge is not acceptable". In a speech at the conference "The Future of Offshore Oil and Gas Development in British Columbia" on October 2, 2001, Mr. Garry Reece, the elected Chief of the Lax kw'alaams Band, clearly stated the concerns of the Lax kw'alaams Band. These included possible negative environmental effects, risk of impacts to marine resources the Band relies upon and potential negative social risk to their culture that would result from large-scale industrial activity. Based on these considerations, the Lax kw'alaams Band is opposed to any change in the moratorium. However, Mr. Reece went on to state that the Band is willing to review its position subject to full and honest dialogue with proponents, leadership roles in studies reviewing the effects of oil and gas developments and opportunities to achieve economic benefits from any development. To ensure that these opinions are understood, the Tsimshian Haida Statement on the moratorium on North Coast Oil and Gas Exploration, the Heiltsuk position and a speech by Chief Gay Reece of the Lax Kw'alaams First Nation are attached as Appendix 2.

3.4 Communities

The potential for oil and gas exploration in Hecate Strait, as noted in the two previous reports (AGRA Earth and Environmental 1998 and Province of British Columbia 1986), could have significant benefits and / or impacts on local district centres of varying sizes. The following describes the state of the economy in many of the centres whose districts are adjacent to the current moratorium area. Specific reference is made to the communities, population, labourforce, and key economic sectors, including fisheries and tourism.

3.4.1 People

There are four districts identified by the provincial government, which border on the current exploration moratorium area. They are:

- Regional District 43: Mount Waddington;

- Regional District 45: Central Coast;
- Regional District 47: Skeena-Queen Charlotte; and
- Regional District 49: Kitimat-Stikine.

All districts have positive growth rates (under 1 percent per year, 10-year average) and labourforce participation rates higher than the provincial average. All districts have a significant public sector and forestry sector contribution to employment, while the mining and fishing and trapping sectors contribute less to district employment. By way of contrast, British Columbia's employment leaders are public sector (24 percent), forestry (20 percent), and tourism (7 percent).

Table 3.4 describes the income dependency by industry for the centres identified above. Income dependency refers to sector contribution to household income within the District. For comparison, provincial statistics are shown at the bottom.

Table 3.4 Income and Sector Dependency, Selected Centres

District	Average Household Income	Income Dependency (1996)	Percentage Share
District 43 - Mount Waddington	60,245		
		Forestry	45
		Public Sector	18
		Fishing/Trapping	7
		Tourism	6
District 45 - Central Coast	41,861		34
		Public Sector	22
		Forestry	8
		Tourism	7
		Fishing/Trapping	
District 47 - Skeena-Queen Charlotte	56,305		
		Public Sector	28
		Forestry	25
		Fishing/Trapping	13
		Tourism	8
District 49 - Kitimat-Stikine	57.636		
		Forestry	25
		Public Sector	24
		Mining	15
		Tourism	6
British Columbia	56,527		
		Public Sector	24
		Forestry	20
		Tourism	7
		Mining	5

Source: BC Stats

Table 3.5 below describes the population, growth rate, and labourforce participation rates of these Districts (including the largest centres for each Regional District).

Tourism (and ecotourism) in communities within the study is a growing industry, and is being encouraged in order to diversify a primary-producer and resource-extraction based economy, and to combat seasonal unemployment. Presently between 6-8 percent of residents are dependent on the tourism-based economy for household income.

Table 3.5 District Population Statistics

District	Largest Centres	Population (2000)	% District Growth Rate (10yr. Avg.)	Participation Rate (1996), %
43 - Mount Waddington	Port Hardy	5,228	0.3	77.5
45 - Central Coast*		4,556	1.8	71.6
47 - Skeena-Queen Charlotte	Prince Rupert	17,027	0.2	74.2
	Masset	1,266	-	-
49 - Kitimat-Stikine	Kitimat	11,533	1.1	70.8
Total, British Columbia		4,063,760	2.3	60

* Bella Coola 1996 population - 873

Source: BC Stats

3.4.1.1 Regional District 43 - Mount Waddington

Port Hardy is the largest centre in RD 43, with a population of 5,228, which accounts for approximately 35 percent of the region's population, though the land area is only 0.2 percent of the region. Port Hardy's economy has a high reliance on forestry and the primary resources sector of the economy and the participation rate is highest in the study area.

3.4.1.2 Regional District 45 - Central Coast

The Central Coast district has port, rail, and road access at Bella Coola. The district population is lower than others in the study area. Education levels and participation rates are comparable to other districts.

3.4.1.3 Regional District 47 - Skeena-Queen Charlotte

Within RD 47, Prince Rupert and Masset account for nearly 68 percent and 5 percent of the region's population and only 0.4 percent (combined) of the region's total land area. However, their size and/or location in the region (as well as existing infrastructure) may prove advantageous for exploration activities.

3.4.1.4 Regional District 49 - Kitimat-Stikine

The city of Kitimat, with a population of 11,533, is the most strategically placed city in the district. The district relies heavily on the forest industry and public sector, both of which are currently giving way to increased tertiary industry as well as tourism initiatives.

Table 3.6 Key Infrastructure and Major Employment Industries

Community	Key Infrastructure/Activities/Facilities	Major Industrial Employers (# employed)
Kitimat	21 greenfield industrial sites (11 on tidewater)	Alcan Smelters (1,800+)
	11,660 ha of developable industrial land	Eurocan Pulp & Paper Co. (630+)
	quarrying opportunities	Methanex (125+)
		Pacific Ammonia Inc
		Rivtow Marine and Barging
Masset	commercial fishing fleet	CB Island Fisheries
	2 Commercial fish processing plants	Omega Packing Company Ltd
		Graham Island Shake and Shingle Ltd
		Delmas Cooperative Association
		Greater Masset Development Corporation
		Northern Savings Credit Union
Port Hardy	fish processing	large commercial fishery (800-1,000 operators)
	wood manufacturing	aquaculture/shellfish operations
	tourism	seafood processing sector
	forestry/silviculture	100 sportfishing charters/outfitters
	varied tourism sector	nearby Provincial Parks
Prince Rupert	780 fishing vessels; 1300 fishermen	Skeena Cellulose Inc. (600+)
	11 processing plants (up to 2,200 employed)	Canadian Fishing Company (150+)
	1,500 salmon licenses	Northern Savings Credit Union (120+)
	largest fish cannery in the world (Allied Pacific Processors)	JS MacMillan Fisheries (100+)
		Ocean Fisheries (100+)
		Prince Rupert Grain (100+)
		Ridley Terminals (70+)
		North Coast Timber (50+)
		Canadian Stevedoring (50+)

Sources: Northwest Development Corridor and Port Hardy and District Chamber of Commerce

3.4.1.5 Education Levels and Labour Supply

Table 3.7 illustrates the percentage of the labour supply (1996 figures) in the principle centres of the study area, as a function of post-secondary diplomas and certificates, and university degrees. Provincial figures are approximately 30 and 14 percent, respectively.

Table 3.7 Labour Characteristics by District

District	Education Level (Post-Secondary Diploma/Certificate), %	Education Level (University Degree), %
43 - Mount Waddington	29.4	7.9
45 - Central Coast	28.5	8.5
47 - Skeena-Queen Charlotte	27	8.1
49 - Kitimat-Stikine	27	8

Source: BC Stats

3.4.2 Fisheries

The fisheries in the region can be divided into four categories:

- commercial;
- commercial-recreational;
- recreational; and
- aquaculture.

The commercial fishery in British Columbia remains a key source of employment and income for the province, and is the key resource sector for many small and medium size communities, and for more remote communities along the central and north coast areas.

Statistics from 1999 show that the salmon, herring, groundfish, wild shellfish, and other fisheries accounted for 210,000 tonnes and a landed value of over $300 Million. However, the 1999 wild salmon harvest was the lowest in 50 years, and has resulted in concerns over conservation. The decline in the salmon industry is being mitigated largely through aquaculture in B.C.

The commercial-recreational fishery in B.C. includes tourism operations of varying sizes, in populated and remote areas. Many of the communities in the study area specialize in this type of eco-tourism, offering the "whole package" to tourists by providing both the lodging and the "fishing" experience, while the industry is also expanding into incorporating other outdoor activities instead of recreational fishing. More detail is given in the Tourism section (Section 3.5.1).

Recreational sportfishing in tidal areas accounted for approximately $315 Million in the 1999 provincial economy, provided 3,400 seasonal jobs, and put to work over 800 charter operators (BC Fisheries).

Salmon farming in B.C.'s aquaculture industry reached 49,900 tonnes in 1999, an increase in nearly 7,000 tonnes from the previous year, and contributed $329 Million (88 percent of total aquaculture wholesale value) in wholesale value to the provincial economy (up nearly $65 Million from 1998). Nearly 80 percent of the salmon aquaculture industry is represented by Atlantic salmon (followed by Chinook at 18 percent and Coho at just over 3 percent). Aquaculture is an expanding sector in the study area, and in some cases, is attempting to offset losses in the traditional fisheries sector.

3.4.3 Challenges Facing Coastal Communities

Declining salmon catches since 1986 have affected the economies of coastal communities, and continue to present a threat to the economic base of communities who rely on the harvesting and processing sectors. The key communities identified above depend on the fisheries sector for employment, as seen in the example of Prince Rupert, which has nearly 800 fishing vessels and 1,300 fishermen (similarly, Port Hardy has between 800 and 1,000 operators in the commercial fishery). Within the processing

sector, major industrial employers in these centres rely heavily on the salmon fishery (for example, there are eleven processing plants in Prince Rupert which, in total, employ nearly 2,200 people). These challenges are made worse by the lack of future prospects for the fisheries sector, and therefore the health of communities whose economy is reliant on fisheries and processing. There is no indication that the effects of depleted salmon stocks on the economy will be short-term in nature.

In the past five years, the Government of Canada has implemented measures to reduce the size of the oversized commercial fleet, as well as fund habitat restoration measures, rebuild salmon stocks, and increase resource and watershed stewardship. Furthermore, the government has funded programs to compensate vessel owners who were affected by certain strategy provisions, and to assist individuals who may have been displaced by these measures. The aim of these measures is to improve the long-term sustainability of the fisheries sector by improving habitat, which will in turn improve salmon stocks. Initiatives are still in place to increase stewardship, compensate for losses, diversify economies, and create an economic atmosphere to foster recovery of salmon stocks.

The forestry sector in the immediate area is also facing some challenges. Notably, one of the biggest issues is the economic health of Skeena Cellulose, in Prince Rupert. Skeena Cellulose was recently granted protection from creditors, with hopes of future ownership in the private sector. The sawmill in Prince Rupert, at full production, can employ over 1,300 employees, and 6,500 more are directly and indirectly employed as a result of the pulp and paper mills and log chipper and sawmill activities in other locations. The loss of Skeena Cellulose would greatly affect the economic base of the regional economy.

Competitiveness in the lumber industry is being hampered by high stumpage rates paid by northern mills and high transportation costs, as compared to other parts of Canada. There are presenting challenges to local industry which, in the key districts outlined above, economies rely heavily upon (household income dependency ranging from 22-45 percent).

3.5 Other Resource Use - Tourism, Sensitive Areas, Port and Shipping

This section addresses the state of the tourism industry in the identified areas, sensitive areas (including Marine Protected Areas), and the Land and Resource Management Planning (LRMP) processes, which are active to varying degrees in the study area. Transportation in key port cities is discussed at the end of the section, outlining infrastructure and facilities for road, rail, and sea access. The tourism industry and the status of land and resource (including marine resources) planning are major factors to consider in any discussion of oil and gas exploration.

3.5.1 Tourism

Many urban centres in the study area have growing tourism industries, or are in the process of establishing tourism operations, many of which are natural-resource based. For the centres of Kitimat, Masset, Port Hardy, and Prince Rupert, the following table elaborates on the existing tourism-amenity

base and indicates the tourism strengths currently in the respective region.

How oil and gas exploration activities could affect the trend toward tourism and ecotourism in the area is unknown, as is the manner in which the industries could complement each other in community economic development.

Table 3.8 Tourism in Selected Centres

Municipality	Characteristics
Kitimat	sportfishing charters (20+)
	MK Bay Regional Marina
	Moon Bay Marina/Kitimat Village Marina
	Mount Layton Hotsprings Resort
	access to Kitlope Rainforest area
	18-Hole golf course
	Furlong Bay and Lakelse Lake Provincial Park
	ski trails
	Weewanmu and Bishop Bay hotsprings
Masset	sportfishing charters (9)
	freshwater and sea-fishing opportunity
	10 local hiking trails
	small craft harbour
	bird watching at Delkatla Wildlife Sanctuary
	ferry and seaplane tours
Port Hardy	sportfishing
	whale watching, sea kayaking
	scuba diving
	nearby Provincial Parks
	9-hole golf course
	nearby ski hill (Mt. Cain)
Prince Rupert	100 sportfishing charters/local outfitters
	whale watching, sea kayaking
	Pike Islands Marine Heritage Tour
	First Nations Archaeological Tours
	Centennial Golf Course
	ferry and seaplane tours

Sources: Northwest Development Corridor and Port Hardy and District Chamber of Commerce

Another aspect of tourism for coastal communities in the area is the Cruise Ship industry. Ports of call (e.g. Prince Rupert, Port Hardy, etc.) on the west coast directly and indirectly benefit from cruise ship activity[1]. There may be a potential for oil and gas industry activities and cruise ship activities to

1 A recent study reported that cruise ship activity in British Columbia resulted in a total regional impact of $282.3 million to the economy (CCG Consulting Group Ltd, 2000).

overlap. The requirements of these two industries may have to be addressed.

3.5.2 Sensitive Areas - Marine Protected Areas (MPAs)

Marine Protected Areas, a joint initiative between the Government of Canada and the Government of British Columbia (and part of the provincial Land Use Strategy), was proposed to be a comprehensive, inclusive strategy to identify sensitive areas along the Pacific coast of B.C., and to provide some level of protection for conservation and sustainability, and to address issues of resource conservation, pollution, habitat alteration, exotic species, and climate change. A discussion paper was released in 1998, but to date, the Strategy has yet to be developed. This is due, at least in part, to difficulties encountered when dealing with shared marine jurisdiction between the federal and provincial governments. The Strategy described in the 1998 discussion paper notes that minimum protection standards for marine protected areas would prohibit ocean dumping, dredging, and exploration for, and development of non-renewable resources.

There are currently ten designation types for marine protected areas in BC, at both the federal and provincial levels. In addition to the federal and provincial designations, there are municipal marine parks; however, they only offer protection for marine resources where Fisheries and Oceans Canada has established fishery closures within the boundaries of the park. There are only two instances in BC where this has occurred.

The provincial government has five designation types for MPAs: Ecological Reserves, Provincial Parks, Wildlife Management Areas, Designated Wildlife Reserves and "Protected Areas". Agency participation and responsibility for these five types of MPAs currently rests with the British Columbia Ministry of Water, Land and Air Protection. Ecological Reserves are crown and private lands designated by the Lieutenant Governor in Council, under the *Ecological Reserve Act*. Ecological Reserves are areas suitable for research and education, representative of natural ecosystems in B.C., examples of modified environments that can be studied for their recovery or are habitats for rare, endangered or unique species. There are four marine Ecological Reserves within the north and central coast areas of B.C.

Provincial Parks are created through Order-in-Council under the *Park Act* or inclusion in a Schedule in the *Act*. The purpose of provincial parks is to set aside representative ecosystems, habitat and special landscapes and features with the broadest diversity of provincially significant biophysical resources. They also serve various recreation functions, including enhancing tourism opportunities and ensuring enjoyment by all residents of the province. There are three classes of provincial parks. Class A parks are dedicated to the preservation of natural environments for the inspiration, use and enjoyment of the public. There are fourteen Class A parks and two Class R parks (Recreation Areas) with marine associations in the north and central coasts of B.C.

Wildlife Management Areas (WMAs) are designated by the Ministry of Water, Land and Air Protection

(MWLAP). MWLAP can acquire and administer lands and designate them as WMAs, except if they are in an existing park or recreation area. Designation of land under a WMA does not affect any rights previously granted. The purpose of WMAs is to encourage appreciation of wildlife values while ensuring wildlife heritage is passed on to future generations by maintaining diversity and abundance of native species and their habitats, opportunities for the use and enjoyment of wildlife and harmony between people and wildlife. There are no marine Wildlife Management Areas on the north and central coasts of B.C.

Sections 15, 16, 17 and 101 of the *Land Act* allow the Province to reserve or transfer Crown land for various reasons in the public's interest. Designated wildlife reserves are mainly used as an interim measure before the ultimate establishment of a wildlife management area. There are 5 wildlife reserves on the north and central coasts of B.C.

The *Environmental Land Use Act* is used to designate areas with both examples of marine diversity, recreational and cultural heritage and special natural, cultural heritage and recreation features. It is used by a Land Use Committee of Cabinet to meet government's land use plan commitments and respond to concerns with the *Park Act*. The Kitlope Heritage Conservancy is the only marine "protected area" on the north and central coasts of B.C.

The federal government also has five designation types for MPAs: National Parks (Reserves), National Marine Parks (National Marine Conservation Areas), Migratory Bird Sanctuaries, National Wildlife Areas and Marine Protected Areas. Parks Canada is responsible for National Parks and National Marine Parks, Environment Canada is responsible for Migratory Bird Sanctuaries and National Wildlife Areas and Fisheries and Oceans Canada is responsible for Marine Protected Areas.

National Parks are created to protect natural environments that are representative of Canada's natural heritage. They are managed by Parks Canada to maintain their ecological integrity while providing opportunities for public understanding, appreciation and enjoyment. A national park is formally established with an amendment to the *National Parks Act*. Because coastal areas of B.C. are currently subject to treaty negotiations, final designation for Gwaii Haanas (and Pacific Rim on the west coast of Vancouver Island) National Park, therefore, it is referred to as a Park Reserve in the interim.

National Marine Conservation Areas (NMCAs) are established to protect and conserve a network of representative areas of the marine environments in Canada while providing education and enjoyment to the people of Canada and the world. The intent is to manage the parks to demonstrate how protection and conservation practices can be harmonized with the sustainable use of marine ecosystems. NMCAs are currently established under the *National Parks Act*; however, a proposed *Marine Conservation Areas Act* is currently before Parliament. An NMCA has been established at Gwaii Haanas and is currently the only NMCA on the north and central coasts of B.C.; however, Parks Canada's NMCA System Plan identifies five of the twenty-nine marine regions in Canada on the Pacific Coast: the Strait of Georgia,

the Vancouver Island Shelf, Queen Charlotte Sound, Hecate Strait and the Queen Charlotte Shelf. Both Hecate Strait and the Queen Charlotte Shelf are represented in the Gwaii Haanas NMCA.

National Wildlife Areas (NWAs) are established under the *Canada Wildlife Act* on lands subject to federal jurisdiction and the administrative control of the Minister of Environment. They may be on land, internal waters or the territorial sea. The purpose of NWAs is to set aside nationally significant habitats for the protection of migratory birds and wildlife for the purpose of research, conservation and interpretation. There are currently no NWAs on the north and central coasts of B.C.

Migratory Bird Sanctuaries are established under the *Migratory Birds Convention Act*, which empowers Canada to enact and enforce regulations to protect those migratory birds listed in the Convention. There are no migratory bird sanctuaries on the north and central coasts of B.C.

Marine Protected Areas are designated, under the *Oceans Act*, by the Governor in Council, on the recommendation of the federal Minister of Fisheries and Oceans. Marine Protected Areas are established to conserve and protect:

- commercial and non-commercial fishery resources and their habitats;
- endangered or threatened marine species and their habitats;
- unique habitats;
- marine areas of high biodiversity or biological productivity; and
- any other marine resource or habitat as is necessary to fulfill the mandate of the Minister.

While no *Oceans Act* MPAs have been formally approved, four pilot MPAs were announced in B.C. in 1998: Gabriola Pass, Race Rocks, the Bowie Seamount and the Endeavour Hot Vents.

3.5.3 Land and Resource Management Plans (LRMP)

The study area includes three areas for which LRMP processes are planned, have been initiated, or are currently in progress. These are: the Central Coast Land and Resource Management Plan, the Queen Charlotte Islands - Haida Gwaii Land and Resource Management Plan, and the North Coast Land and Resource Management Plan. The LRMP process will guide the management of lands and activities which could affect the region's ecosystems, amenities, and socio-economic environment. The Ministry of Sustainable Resource Management (MSRM) and the Land Use Coordination Office (LUCO, now the Resource Planning Division of the BC MSRM) work in conjunction with resource ministries to inform, develop, and implement LMRPs. LRMPs generally provide:

- broad land use zones defined on a map;
- objectives that guide management of natural resources in each zone;
- strategies for achieving the objectives; and,
- a socio-economic and environmental assessment that evaluates the plan. (BC MSRM, 2001)

The LRMP process is designed to be focused on ecosystem, social, cultural, and economic sustainability to determine current and future land-use. Decision-making is open and community based so that the needs of communities, the economy, and the environment inform resource management decisions. The recently initiated Central Coast Preliminary LRMP has instituted an ecosystem-based management system. Any activities related to oil and gas exploration with the potential to affect regions in the study area would necessarily have to take into account an existing LRMP or a planning process towards the establishment of a LRMP. Depending on the nature and precise location of exploration activities, one or more LRMP area may be directly involved. However, areas under the LRMP system would not include offshore or marine areas beyond the coastal zone.

The LRMP process is designed to identify sensitive and critical areas of importance to the ecosystem, local communities, and First Nations. The importance can be ecological, economic, or social in nature, and thus the LRMP process relies on stakeholder participation.

3.5.3.1 Central Coast LRMP

The Central Coast LRMP process is still underway. The provincial government has accepted the Central-Coast's land-use table, which includes portions of the Great Bear Rainforest (96,458 hectares designated as the Spirit Bear protection area), pending consultation with 17 First Nations who are currently participating in the planning process. This area is environmentally and culturally significant in the region, and has implications for local economic development stakeholders in various sectors. Completion of The Central Coast LRMP will rely on agreement with the First Nations.

3.5.3.2 Queen Charlotte Islands - Haida Gwaii LRMP

The Queen Charlotte Islands-Haida Gwaii (QCI) LRMP process has been initiated, but to date there is no LRMP in place. Consultation with the community, the First Nations in the region, and other stakeholders is being carried out. The provincial government has released a background report entitled "An Overview of Natural, Cultural, and Socio-Economic Features, Land Uses and Resources Management". The area includes 150 islands, 4,700 km of shoreline, and approximately 4,000 waterbodies of varying sizes. The area is home to over 240 species of birds, over 300 species of fish, 39 species and subspecies of plants and animals unique to the islands, and 116 exotic species.

Economically, the region is largely dependent on the tertiary/service sector (tourism and government - 68%), with 24% relying on the primary sector, mainly based on resource extraction such as logging and fishing. The Haida Nation is a strong voice in the community, and comprises a large portion of the population. There are two federally designated "Indian Reserves" in the region (Old Masset and Skidegate). The Haida Nation in conjunction with the Government of Canada cooperatively manage the Gwaii Haanas National Park Reserve, in the southern portion of Haida Gwaii. The site is a World Heritage Site which encompasses approximately 1,900 islands and islets.

It is expected that the QCI LRMP process will proceed in a manner much like the typical LRMP

process, establishing overall objectives, economic objectives, environmental objectives, and social objectives, representing values and interests from a wide variety of stakeholders.

3.5.3.3 The North Coast LRMP

The North Coast LRMP process is not yet initiated. Mapping provided by the Province of B.C. shows that there are many marine and inland areas that fall within the LRMP region. It is fair to say that the direction taken by the underway Central Coast LRMP process and the upcoming QCI LRMP process would dictate direction taken in this region, and the types of sensitive and/or socio-culturally significant areas in the region would be similar to those found in adjacent LRMPs.

Where LRMPs are not yet in place, there may be other planning processes undertaken by the Ministry of Sustainable Resource Management that consider aquaculture, integrated resource use, or both.

3.5.4 Port and Shipping Activities

The port cities of Kitimat, Masset, Port Hardy and Prince Rupert are described in Table 3.7. The table briefly highlights transportation infrastructure from land and sea.

The Port of Prince Rupert is strategically located, with the largest installed infrastructure and port capacity. Statistics from Transport Canada note that the Prince Rupert port is frequently operating at excess capacity. Grain has constituted up to 35 percent of Prince Rupert's total export volume, and recently the port has been underutilized. Other centres selected within the study area offer shipping, storage and transportation infrastructure in various capacities, as seen in the table below.

Table 3.9 Rail, Road and Port Infrastructure, Selected Centres

Municipality	Rail	Road	Water
Kitimat	56 rail cars/day (avg), CN freight line extends across North America	Interprovincial Highway 37 via Highway 16 (links to Prince George and Edmonton)	container port facility (port handles 260+ vessels/year, exports over $1 Billion (1997))
	freight and passenger service (North-South)	Established freight industry; easily expandable rail cargo capacity	space for 11 tidewater terminals and manufacturing operations
Masset	-	TransCanada/Yellow-head Hwy (Graham Island Terminus of Hwy 16 to Skidegate)	BC Ferries services (Skidegate-Prince Rupert)
Port Hardy	CN Freight line for grain export	Highway 19 links to Victoria and other island centres	BC Island ferry service
			port development for deep sea ships and barges
Prince Rupert	CN Freight line	TransCanada Hwy (Hwy 16)	BC Ferries / Alaskan State Ferries service
	BC Rail north/south passenger/freight service	Established trucking industry infrastructure	6 terminal facilities (incl. 1 cruise terminal) - cargo, coal, grain, storage facilities.

Source: Northwest Development Corridor and Prince Rupert Port Authority

4.0 PHYSICAL ENVIRONMENT

In this section, the physical environment in the proposed exploration areas is reviewed and, where possible, compared with conditions in other areas where offshore hydrocarbon exploration and development activities are taking place. The focus of this section is on the physical environment as it relates to geohazard assessment, engineering design parameters, operational and safety concerns, and environmental impact assessment. The intent is to discuss the quantity and quality of available information from the perspective of defining conditions on a regional basis, given that any exploration activities will be preceded by detailed site work by the leaseholder. Detailed technologies and engineering implications are discussed in Section 5.

4.1 Physiography

The main areas of interest for future oil and gas exploration are the Queen Charlotte and Hecate Basins as outlined in Figure 4.1 (Terra Remote Sensing Inc. 1999). The high potential zones extend roughly from the north end of Vancouver Island through Queen Charlotte Sound and the western portion of Hecate Strait, including Dixon Entrance and the west coast of the Queen Charlotte Islands out to the Queen Charlotte Fault Zone.

The entire area is part of the Hecate Depression, a continuous, low-lying region extending from Puget Sound north to Alaska (Thomson 1981). The Hecate Depression is flanked by the Coast Mountains on the mainland side to the east, and by the open Pacific and the lower mountains of the Queen Charlotte Ranges to the west. The major physiographic features of this region are described in detail elsewhere (e.g. B.C. Ministry of Environment 1983, Petro-Canada Inc. 1983).

Coastal conditions are extremely varied, ranging from dynamic beaches with extensive sand flats to steep cliffs and deep fjords. The physical and biological characteristics of the shore zone throughout British Columbia are currently being mapped using a consistent approach based on a combination of oblique aerial video imagery and selected ground-truthing. The resulting data are then compiled into standard format databases, with an effective "data scale" of roughly 1:5000 (Howes *et al.* 1997). Although the aerial videography has been completed for the entire province, the associated databases are still under development. It is expected that the databases will be completed and become available to the public in the fall or winter of 2002 (Mark Zacharias, pers. comm.).

In a related effort, the Land Use Coordination Office (LUCO) is developing coastal resource and oil spill response atlases for the coast of British Columbia. The oil spill response atlases will incorporate information on biophysical characteristics of the shoreline, sensitivity to oiling and available technologies for oil spill response and cleanup. It is expected that these products will also be completed in the fall or winter of 2002. More information on coastal mapping initiatives is available through the LUCO website at http://www.luco.gov.bc.ca/coastal/mris/coasthm.htm.

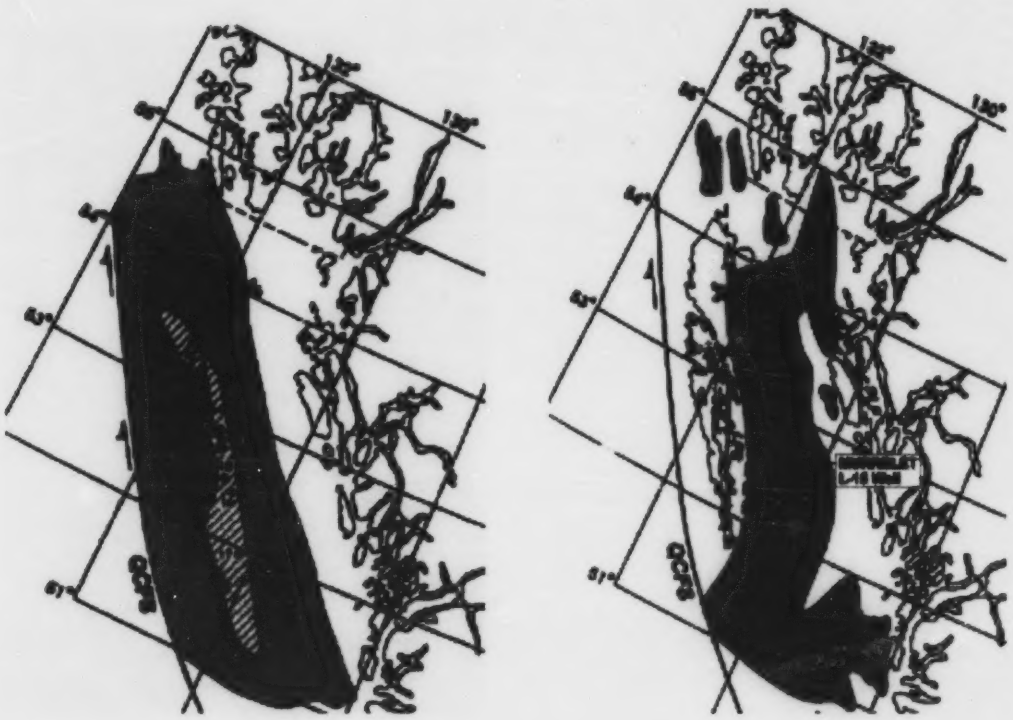


Figure 4.1 Oil and gas plays on the west coast. (Left: Cretaceous oil and gas play; yellow area is the more prospective region with moderate to high potential; Right: red area shows region of the Miocene oil and gas play. Pliocene play covers the northern portion of area north of the Murrelet L-15 well (from TRSI, 1999)).

4.1.1 Bathymetry

Queen Charlotte Sound, the southernmost waterbody under consideration in this review, includes the waters between the north end of Vancouver Island and Cape St. James at the southern tip of Moresby Island. Three major troughs, with water depths extending to 400 m, cut across the sound. Between the troughs lie the shallower waters of Cook Bank, Goose Bank and North Bank, with depths as shallow as 31 m over the eastern edge of Goose Bank (WCOEEAP 1986).

Hecate Strait lies to the north of Queen Charlotte Sound, between the mainland and the Queen Charlotte Islands. The strait narrows from about 120 km between the mainland and Cape St. James at the southern tip of the Queen Charlotte Islands, to roughly 55 km between Rose Spit and the mainland. Much of the western half of Hecate Strait consists of two shallow banks with water depths consistently less than 40 m: Dogfish Bank to the north and Laskeek Bank to the south. On the mainland side, a submarine valley deepens from 50 m in the north to 300 m in the south and continues southward and westward to the open ocean through the troughs on either side of North Bank in Queen Charlotte Sound (Figure 4.2).

Dixon Entrance is a broad east-west channel separating Graham Island from the islands of the southern Alaska Panhandle. Water depths decrease from 400 m where the channel meets the Pacific Ocean to 200 m at the mainland side. At its seaward end, Dixon Entrance is divided into two deep channels by a large shoal called Learmonth Bank that rises to within 35 m of the water surface. Dixon Entrance is largely separated from the waters of Hecate Strait to the south by Rose Spit, an extensive, dynamic feature protruding seaward more than 12 km to the northeast of Rose Point (Thomson 1981).

The western shore of the Queen Charlotte Islands is steep and rugged and drops sharply to water depths of more than 100 m. The continental shelf in this area is extremely narrow, extending offshore for less than 5 km off of Cape St. James to the south and up to 30 km in the north before the shelf break is reached at roughly 200 m water depth (Barrie and Conway 1996). The offshore areas of interest for oil and gas exploration extends beyond the shelf to water depths of about 2,100 m.

Figure 4.2 Oblique shaded-relief depiction of the topography and bathymetry of the Queen Charlotte area (from Sawyer 1989).

The regional bathymetry has a major impact on ocean currents and circulation patterns, water column mixing processes, wave conditions in coastal areas and areas of sediment deposition or erosion. An accurate knowledge of water depths and seabed slope angles is also required in order to select appropriate drilling units, to safely choose locations for any seabed installations and to identify operational hazards related to shipping activities.

Regional bathymetry of Dixon Entrance, Hecate Strait and Queen Charlotte Sound is covered by Canadian Hydrographic Service Charts 3802, 3902 and 3744, at scales of 1:200 000, 1:250 000 and 1:365 100, respectively. Larger scale, more detailed charts are available for many of the nearshore areas in this region, but these do not provide complete coverage of the main water bodies of concern to this project. Larger-scale field sheets used in the development of Charts 3802, 3902 and 3744 are also available through the Canadian Hydrographic Service (CHS).

All three charts are in fathoms and feet and are based on survey data collected prior to the 1970's and, in some areas, the 1940's. A metric version of chart 3802, numbered 3800, is currently under development. Additional data not incorporated into the existing charts, but collected over the period from 1973 through 1985, are available through CHS. These data consist of single beam echosounder readings at a 10 km line spacing. Data coverage on the west coast of the Queen Charlotte Islands is typically poor, given the dangerous conditions in the area and the low demand for charts of this region. In general, chart accuracy is approximately 1 percent of water depth (Terry Curran, pers. comm.).

Water depths in the proposed exploration areas are similar to those where offshore oil and gas production facilities are currently operating on both the Scotian Shelf and the Grand Banks of Newfoundland. However, both local slope angles and spatial variability in bottom topography are much higher than those encountered on the eastern shelves, even away from the coastline. Many relict beaches and drowned coastal features persist on the offshore banks and shoals, primarily as a consequence of the rapid, post-glacial sea level rise, the historically sheltered nature of the inland seas and the proximity to a tectonic margin (Vaughn Barrie, pers. comm.). These features require detailed hydrographic survey techniques, such as the swath bathymetry approach described in Section 5.1.3.2.

4.1.2 SEAMAP

The Seabed Resource Mapping Program (SEAMAP) is a national initiative to map Canada's offshore, coastal and aquatic lands. The initiative is supported by three federal government departments (Fisheries and Oceans, National Defence and Natural Resources) and is proposed as a partnership between industry, government and Canadian universities. The intent of the initiative is to provide data and products for users in the fishing industry, fisheries management, offshore oil and gas, offshore engineering, aquaculture, national defense, aquatic, coastal and ocean management, and scientific research; all within a national framework (http://seamap.bio.ns.ca).

SEAMAP is currently at the proposal stage, under consideration by the Federal Cabinet. While reviews to date have been excellent, it is not known at this stage if funding will be approved for this initiative. If approved, the program will likely start with demonstration projects in key areas of Canada, as identified on a national basis. Mapping of the Queen Charlotte Basin has already been established as a regional priority for the west coast (Richard Pickrill, pers. comm.).

The technical approach to seabed mapping will focus on the use of swath or multibeam bathymetry systems, accompanied by appropriate ground-truthing. While the technologies are currently available to proceed with such an initiative, the commitment of sufficient resources by the federal government is required in order to proceed (Richard Pickrill, pers. comm.).

4.2 Climate

The north coast of British Columbia has a temperate climate regulated by the prevailing onshore flow of marine air. On a large scale, regional climate and weather patterns are dominated by two atmospheric pressure systems: the North Pacific High and the Aleutian Low. The North Pacific High dominates in summer months, producing north to northwesterly winds along the outer coast. In winter months, the Aleutian Low becomes dominant, producing winds from the south to southeastern sectors. These prevailing wind patterns are modulated by coastal topography and are interrupted for days or weeks by eastward-migrating high and low pressure systems, which can produce intense storms (Thomson 1981).

Climatic conditions impact both operation and safety of offshore drilling activities. A discussion of climate can be separated into two parts: conditions during normal, or average, periods and those during extreme events. In general, extreme events govern the design parameters which impact the safety of offshore operations, while normal conditions are more important for operational considerations, structural fatigue issues and in assessing and controlling environmental impacts associated with offshore hydrocarbon exploration and development activities. Normal meteorological conditions will be addressed in this section, with storm events described in Section 4.4.

The day-to-day meteorological factors affecting offshore drilling operations include winds, temperature, visibility and ceiling, wind chill and freezing spray (Petro-Canada 1983). An extensive system of land-based climatological stations is operated by the Atmospheric Environment Service (AES) of Environment Canada throughout the coastal areas of British Columbia. Parameters reported from these stations include radiation, humidity, pressure, visibility and cloud cover, temperature, precipitation and wind. Over 30 years of measurements are available for many coastal stations in British Columbia (AGRA 1998).

Petro-Canada (1983) performed extensive analyses of the historic records from land-based climatological stations surrounding Dixon Entrance and Hecate Strait. Based on the existing database at that time, Petro-Canada concluded:

> "Temperature extremes, wind chill and freezing spray are unlikely to pose serious problems to drilling operations off the Queen Charlotte Islands. Occasionally visibility and ceiling height would be low enough to restrict aircraft operations. Visibility is poorest in the summer and fall when advection fog occurs, and low ceilings are common in winter. The simultaneous occurrence of low visibility and low ceiling is rare."

Although many of the land-based climatological stations examined by Petro-Canada have since been decommissioned (Gary Myers, pers. comm.), the remaining stations, such as Sandspit, Langara and Cape St. James, will now have almost 20 years of additional measurements. Up-to-date information on available climate data can be obtained through the Climate Station Database maintained by AES (http://www.msc-smc.ec.gc.ca/climate/station_catalogue/index_e.cfm).

While it would certainly be worthwhile to update the analyses of historic climate data to include the more recent measurements, it is not expected that the above conclusions would change in any significant manner. The impacts of climate change are discussed in Section 4.5 of this report.

4.2.1 El Niño and La Niña

El Niño is a disturbance in the natural cycle of the ocean and atmosphere in which a warming occurs in the tropical sea surface waters of the eastern and central Pacific Ocean. This warming adds considerable amounts of heat and moisture to the earth's atmospheric circulation at the tropics resulting in large-scale changes to the earth's atmospheric circulation particularly at the tropics and to a lesser extent elsewhere around the globe. This occurs every two to seven years. La Niña is the cooler phase counterpart to the ENSO and weather conditions are in general opposite to those occurring during El Niño.

Impacts on British Columbia from El Niño include milder air temperatures, warmer coastal waters, rises in sea level, and a reduction in snowfall. The effects on total precipitation (rain and snow) vary considerably across British Columbia. While short-term changes in weather patterns are associated with the ENSO, it is not expected that this phenomenon would have a significant impact on the design and safety of offshore facilities.

4.3 Water Level and Ocean Currents

Variations in water levels are caused by several factors--of these, tides are by far the most significant in the northern coastal waters. Tides within the area of interest are mixed, predominantly semi-diurnal, meaning that there are two complete tidal exchanges per day. However, the mixed nature of the tides leads to significant inequalities in both the magnitude and the duration of successive exchanges.

In coastal waters, tides interact with bathymetry in a number of ways, leading to significant spatial variations in tidal range and timing of high and low water stands. In the waters surrounding the Queen Charlotte Islands, the mean tidal range varies from 3.0 m at the entrance to Queen Charlotte Sound to 4.8 m midway along Hecate Strait, and from about 3.5 m at the mouth of Dixon Entrance to 5.0 m at Prince Rupert. On a large tide, ranges can exceed 7 m at several coastal locations (Thomson 1981).

In addition to tides, significant variations in water level can result from factors such as storm surge; large scale, periodic, climatic cycles such as El Niño/La Niña; and the local effects of river runoff. Variations in water level are continuously measured at several permanent stations around the north coast

(reference ports); shorter records have been obtained from the many secondary ports on both the Queen Charlotte Islands and the mainland coast. In general, knowledge of water level variations in the region is good (Bill Crawford, pers. comm.). Details on the locations of the primary and secondary ports can be obtained from the Canadian Hydrographic Service.

Tidal variations in water level are the primary driving force for ocean currents throughout the coastal waters of British Columbia. However, winds and freshwater inputs are also important contributors to the ocean current regime. As for the general climate in the region (Section 4.2), the ocean climatology can be roughly divided into summer and winter seasons based on the predominant wind direction. All three driving forces (tides, winds and freshwater inflows) interact with the local bathymetry to form complex circulation patterns throughout the region.

Knowledge of ocean currents is required for both engineering and environmental aspects of offshore exploration and development. The magnitude of currents impacting either fixed or floating structures plays a role in assessing structural loads, anchoring requirements, and expected scour depths. Current strength may also impact the timing of sensitive operations such as reconnecting to a wellhead. From an environmental perspective, the ocean currents in the area of an oil spill are perhaps the single most important factor determining the ultimate fate of spilled oil in the environment.

While it is a common requirement that exploratory drilling be preceded by site-specific current measurements by the operator, a broader-based knowledge of current conditions is still required in order to place the site-specific measurements into the context of regional and longer-term processes. The WCOEEAP (1986) recommended that:

> "...the Department of Fisheries and Oceans develop and implement a program to improve general knowledge of current movements in the region, and, in particular, in the area of a drilling location when one is proposed."

As a result of this recommendation, Fisheries and Oceans Canada implemented a major ocean research program in northern waters. Between 1989 and 1995, DFO undertook an extensive measurement program, including moored current meters, tide gauges, ocean drifters and measurements of water properties. This work has been funded by the Panel for Energy Research and Development (PERD) and DFO, with the primary goal of establishing a basic understanding of surface flows in the event of an oil spill. The focus of the field work was on summer conditions, based on the Panel's recommendation to limit drilling activities to summer months. A summary of the research program and the associated publications can be viewed at http://www.pac.dfo-mpo.gc.ca/sci/osap/projects/qci/qci.htm.

Figure 4.3 shows the locations of current meter moorings in northern waters for the period from 1982 through 1995. Records varied in length between two and eight months.

In addition to the field measurement program, a series of numerical models have been applied to these waters (Hannah *et al.* 1991; Foreman *et al.* 1993; Ballantyne *et al.* 1996; Cummins and Oey 1997). These models vary in the numerical approach, grid formulation and resolution, and in the specific processes included in each model.

In summary, the existing database provides a reasonable picture of surface flows during summer months based on the ocean drifter data, and a good picture of regional, sub-surface flows from the moored current meters. Information on surface flows in winter months is limited, and measurements on the west coast of the Queen Charlotte Islands are insufficient to characterize flow patterns in that region. Long-term measurements, including the significant effects of the ENSO, are also not available at this time (Bill Crawford, pers. comm.).

Figure 4.3 Current meter mooring sites for the period 1982 through 1995 (courtesy of W. Crawford, Fisheries and Oceans Canada).

With respect to understanding the regional processes, the various numerical models give a reasonable picture of tidal currents in northern waters, with the exception of Dixon Entrance, where internal tidal currents are significantly under-predicted (Crawford *et al.* 1998). Finer-resolution models may improve this predictive ability. Predictions of maximum tidal current speeds from an updated version of the Foreman et al. (1993) model are shown in Figure 4.4.

Since 1995, work has continued on defining the regional circulation patterns, and has focused on features such as the region around Cape St. James. The flow in this region is dynamic and complex, with current speeds reaching 2.5 ms^{-1}. Flow close to the cape is so turbulent that surface waters cool as they pass by, through the effects of mixing with deeper water (Crawford *et al.* 1995). A persistent plume of cold water is evident well to the west of Cape St. James on satellite images (e.g.

http://www.pac.dfo-mpo.gc.ca/sci/osap/projects/qci/qci.htm), indicating the importance of the Cape to regional circulation patterns. Evidence also exists for a re-circulation of water in the region to the east of the Cape (Crawford *et al.* 1995).

In comparison with other regions of Canada, where offshore hydrocarbon exploration and development activities are currently underway, the ocean currents and circulation patterns in the northern waters of British Columbia are complex and highly variable. Associated with this complexity is a high degree of uncertainty, particularly with respect to predicting the fate of contaminants discharged to the marine environment. This complexity and variability is a consequence of several factors, but is strongly related to the combination of complex bathymetry (Figure 4.2) and large tidal exchanges.

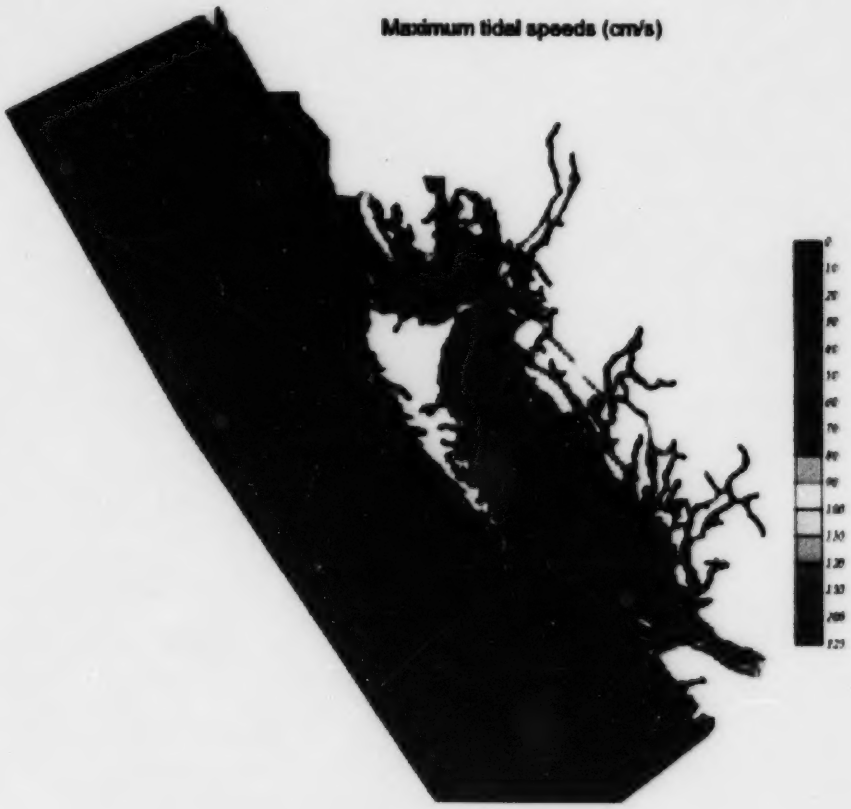


Figure 4.4 Maximum tidal current speeds in northern British Columbia water (courtesy of M. Foreman, Fisheries and Oceans Canada).

4.4 Storm Events

The normal climatic conditions described in Section 4.2 are routinely disrupted by storm events associated with eastward-migrating low pressure centres. These depressions follow two major tracks: one group originates in the northwest Pacific and moves northeastward along the Aleutian Islands, reaching the Alaska coast as fully-developed cyclones; while the second group originates in mid-ocean and reaches the coast of British Columbia at the height of storm development, causing severe winter gales.

The storm activity off the British Columbia coast is distinctly seasonal, with most summer storms following the northern track to the Alaska coast. In October, storm frequency and intensity increase rapidly with more storms following the southerly track. Throughout the winter months, storms regularly reach the coast at two- to three-day intervals. There is a gradual decrease in storm activity through April and May as the storm pattern, frequency and intensity return to summer conditions (Petro-Canada 1983).

Strong winds, high seas and strong currents are produced by storm events. These factors typically determine the maximum environmental loads on marine structures and thus the safety of various structural elements, but also limit the conditions under which various drilling-related operations can proceed. Knowledge of the wind, wave and current conditions at a proposed drilling site is required to choose safe equipment for that site and to select the most effective equipment to maximize the efficiency of drilling operations.

Table 4.1 Design Parameters For Typical Drilling Units (Petro-Canada 1983)

Drilling Unit	Operating Limits	Survival Limits
Drillship		
wind speed (kmh^{-1})	90	185
current speed (cms^{-1})	80	100
wave height (m)	10	30
wave period (s)	<10	>10
Semisubmersible		
wind speed (kmh^{-1})	110	185
current speed (cms^{-1})	100	100
wave height (m)	15	30
wave period (s)	<14	>14

Note: To restrict drilling activities, operating limits for wind, current and sea state must be exceeded concurrently.

Table 4.1 shows the design parameters and operating limits of a typical drillship and semi-submersible, circa 1980 (from Petro Canada 1983). These limits should be considered only as a general guide, since available equipment is continuously evolving with both development of new types of drilling units

together with refined designs for existing platform types (see Section 5.2). Bottom-founded drilling units such as jack-up platforms and gravity-based structures (e.g. Hibernia) do not have the same limitations.

From an environmental perspective, storm-driven currents may be the most significant factor impacting the fate and dispersal of contaminants discharged to the marine environment, while sea state parameters will influence the design and effectiveness of oil spill contingency plans and equipment.

In addition to defining the wind, wave and current conditions to be expected during a storm event, the speed during which storms can cause operating conditions to deteriorate is a significant aspect of determining routine environmental safety (WCOEEAP 1986). In its report, the Environmental Assessment Panel concluded that six hours notice of impending storms is the minimum time required to temporarily cease operations, make the drillstring secure and safely disconnect from the wellhead. The Panel recommended that approval for exploratory drilling not be given until the Atmospheric Environment Service of Environment Canada is satisfied that the capability exists to provide a minimum of six hours advance warning of severe storms.

While storms are of significant concern, the predictable storm events off the British Columbia coast are of lower intensity than those faced by offshore structures in other areas of the world (see Section 4.4.1).

4.4.1 Winds

The waters surrounding the Queen Charlotte Islands are commonly reported as the windiest in Canada, with severe winds more common than in other areas (WCOEEAP 1986). The strongest wind ever recorded for Cape St. James is 177 kmh^{-1}, recorded during a storm in January 1951. At that time, winds were recorded only every six hours; the lighthouse keeper estimated that winds had reached a steady 200 kmh^{-1} with gusts to 225 kmh^{-1} during the peak of the storm (Petro-Canada 1983).

Extreme wind speeds are typically estimated from long-term data records in the area of interest. In addition to the land-based climatological stations discussed in Section 4.2, the Atmospheric Environment Service and DFO together maintain a set of marine weather buoys in northern waters. The marine weather buoys were installed between 1987 and 1993, providing roughly 10 years of historical data for wind-over-water conditions. Station locations are shown in Figure 4.5, and parameters measured at each type of station are given in Table 4.2. The MAREP station shown on Figure 4.5 reports the same data as the climatological stations, identified as marine weather reporting stations on Figure 4.5. However, the MAREP station also reports weather information on VHS radio.

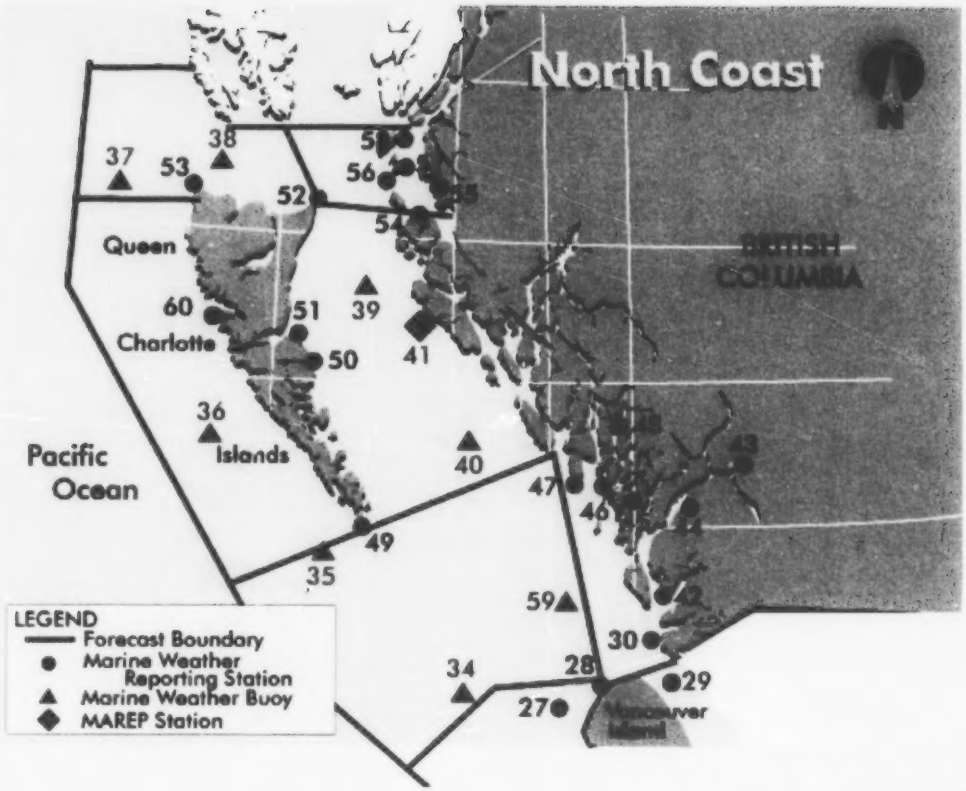


Figure 4.5 **Locations of land-based marine weather reporting stations (including MAREP station) and marine weather buoys in northern British Columbia waters.**

Table 4.2 **Parameters Reported at Marine Weather Observation Stations (after AGRA 1998)**

Met-Ocean Parameter	Station Type	
	Marine Weather Reporting Station	Marine Weather Buoy
Air Temperature	T	T
Pressure	T	T
Wind Speed and Direction	T	T
Wave Height		T
Wave Period		T
Sea Temperature		T
Limited readings from some stations:	T	
Visibility	T	
Sky Cover/Precipitation	T	

Although the wind speeds in northern British Columbia waters are high, similar conditions are also experienced in other areas of the world where offshore hydrocarbon exploration and development activities are currently active. In the Gulf of Mexico, tropical cyclones reaching hurricane speed

(exceeding 120 kmh^{-1}) are the largest factor leading to weather-related shut-downs; most companies include 5 to 7 days of weather-related production losses each year in their business plans (Epps 1997).

Extreme winds over Canadian waters have been estimated as part of the wave hindcasting projects described in the next section (Canadian Climate Centre 1992). A brief comparison of the regional distributions of 50- and 100-year return period wind speeds for each coast shows that extreme wind speeds are roughly 10% higher for the eastern continental shelves, with six-hour values reaching 119 kmh^{-1} in areas where hydrocarbon production activities are already in progress. In comparison, the offshore facilities in the Gulf of Mexico are regularly exposed to wind speeds that exceed the maximum values estimated for both the east and west coasts of Canada.

4.4.2 Surface Waves

Given the close relationship between storm winds and surface waves, wave conditions in the northern British Columbia waters can also be considered relatively severe. Extreme wave conditions are typically estimated from a combination of historic record analyses and numerical modelling of previous extreme storm events (hindcasting).

In addition to the buoy locations shown on Figure 4.5, AES and DFO maintain weather buoys offshore from the coast of British Columbia. Of the total of 17 buoys, eight are shown in Figure 4.5, three are located in the Strait of Georgia, two off of the west coast of Vancouver Island, and three offshore buoys are located about 400 km to the west of the British Columbia coast. All buoys were installed between 1987 and 1993; in general, the period of record is longer for the offshore buoys than for the coastal network. Short-term, historical data are also available for a number of primarily nearshore sites (e.g. Prince Rupert, Kincolith, Kitimat, Port Simpson).

Marine observations of wind conditions and sea state are also available from platforms of opportunity, including both ships and fixed platforms such as drilling rigs. Although this database can be extensive in areas close to major shipping lanes, this type of observation is considered to be significantly less reliable than those obtained from the weather buoys.

Wave hindcasting is relied on world-wide to estimate extreme wave conditions for engineering design purposes (e.g. the 100-year return period wave) in areas where the measurement database is insufficient for this purpose (most offshore areas). In wave hindcasting, sea state conditions are estimated for historic extreme storm events using a combination of numerical modelling and other analysis techniques. Extreme storm events are typically identified using a variety of criteria, and, in the absence of direct wind measurements, wind fields are developed from atmospheric charts for each storm event. These wind fields are then used to estimate site-specific wave conditions in the area of interest for each storm event. The resulting long-term simulated database is then used to estimate extreme wave parameters. Available wind and wave measurements are used to calibrate and verify the numerical modelling and analysis procedures.

A wave hindcasting study for the British Columbia coast was completed in 1992 for the Atmospheric Environment Service (Canadian Climate Centre 1992). This study was part of a multi-part project to estimate extreme wind and wave conditions for Canadian offshore waters. Project results indicated that extreme wave conditions are similar for the west coast of Canada and for the eastern continental shelves, with 100-year return period significant wave heights on the order of 13 m for both the Grand Banks of Newfoundland and the exposed areas of the west coast. It should be noted that the methodology used in these studies predicts deep-water wave conditions only; the effects of shallow water and strong currents on wave heights were not considered.

Since the early 1990's when the extreme wave studies were completed for Canadian waters, the impacts of several extreme storm events on both coasts of North America have prompted the re-assessment of wind and wave hindcast procedures. This re-assessment has focused on the accuracy of the wind fields used to predict wave conditions. The development of wind fields from atmospheric pressure charts uses a combined quantitative and qualitative approach, and thus relies on the expertise of the hindcaster.

In recent years, wind prediction methods have been improved and new wind fields developed for historic storm events (e.g. NCEP-NCAR Renalysis Project (NRA)). These wind fields have recently been used to produce a 40-year wind and wave hindcast for the North Atlantic (http://www.oceanweather.com/aes40). High quality wave measurements allowed evaluation of the accuracy of the wind fields. Although the NRA wind fields were found to produce wave hindcasts of good quality, wind fields still required reanalysis and enhancement using analyst-interactive techniques (Swail and Cox 2000).

For the B.C. coast, the 1992 estimates of wind and wave extremes could be updated based on the improved wind and wave climate databases, and also considering advancements in techniques for predicting wind fields in addition to inclusion of the effects of shallow water and strong currents. Given the large grid size of the NRA wind fields (2°), it is not clear if they will be appropriate for predicting wave conditions in coastal B.C. waters.

4.4.3 Wind-Driven Currents

In addition to creating surface waves, storm winds have several impacts on ocean currents and circulation patterns. In open ocean conditions, winds will create surface currents flowing in the downwind direction at a few percent of the wind speed. In shallower waters, interactions between the wind forcing and the bathymetry can lead to considerably more complex circulation patterns. In nearshore waters where freshwater inputs can lead to density stratification of the water column, the response to wind forcing is yet more complicated.

Several modelling efforts have contributed to our understanding of ocean currents and circulation patterns in the waters surrounding the Queen Charlotte Islands. In addition to the studies mentioned in

Section 4.2, Crawford et al. (1999) have modelled the response of these waters to wind forcing. For this exercise, the local winds measured at the AES buoys (Section 4.4.1) were used to drive the model, and comparisons were made with the summer drifter studies. Limited data were available to verify model predictions for the more extreme winter storms.

4.4.4 West Coast Marine Weather Forecasting

The state of marine forecasting for the west coast of British Columbia, particularly the north coast, has significantly improved since the mid-1980's. Specific improvements were sought at that time in the areas of storm event forecasting and advance warning time. The occurrence of a "marine bomb" event, or rapidly developing low pressure system, in October 1984 in which several fishing vessels were lost was a contributing factor to this need for improvement, as was the direct observation of wave conditions reaching or exceeding the 100-year return period event during several other storms.

The Environment Canada weather office and forecast operations for the Pacific and Yukon regions are based in Vancouver. The west coast marine weather forecast areas presently served are illustrated in Figure 4.6 *(http://www.weatheroffice. ec.gc/NatMarine/BC/index.html). A dedicated marine forecast desk, for both nearshore (coastal and 50-100 km out) and offshore marine areas, has been in operation since 1985 and considerable experience has been accumulated since that time. The forecasting unit operates on a 24 hour, seven days a week basis, and issues wind and sea state forecasts every six hours which cover the subsequent 24 hours with an outlook for the following 24 hours.*

Marine forecasts consist of two parts: a descriptive synopsis of the prevailing weather patterns, plus a detailed weather forecast. A sample for Hecate Strait is listed below.

> **Synopsis:**
> A ridge of high pressure along the coast will move inland tonight.
> A rapidly deepening low will track northwards to lie about 250 miles west of the Charlottes tonight. The associated front will sweep over the Charlottes Monday afternoon and reach the lower mainland Tuesday morning. A trough of low pressure will follow across the Charlottes Monday night.
> Over northern waters winds will rise to gale force southeast tonight. A brief period of storm force winds is expected Monday morning in advance of the front. Winds will ease to strong southerly with the passage of the front. Southerly gales ahead of the trough will shift to strong to gale force westerlies in its wake.
> Over southern waters winds will back into the southeast and rise to strong to gale as the front nears Monday.

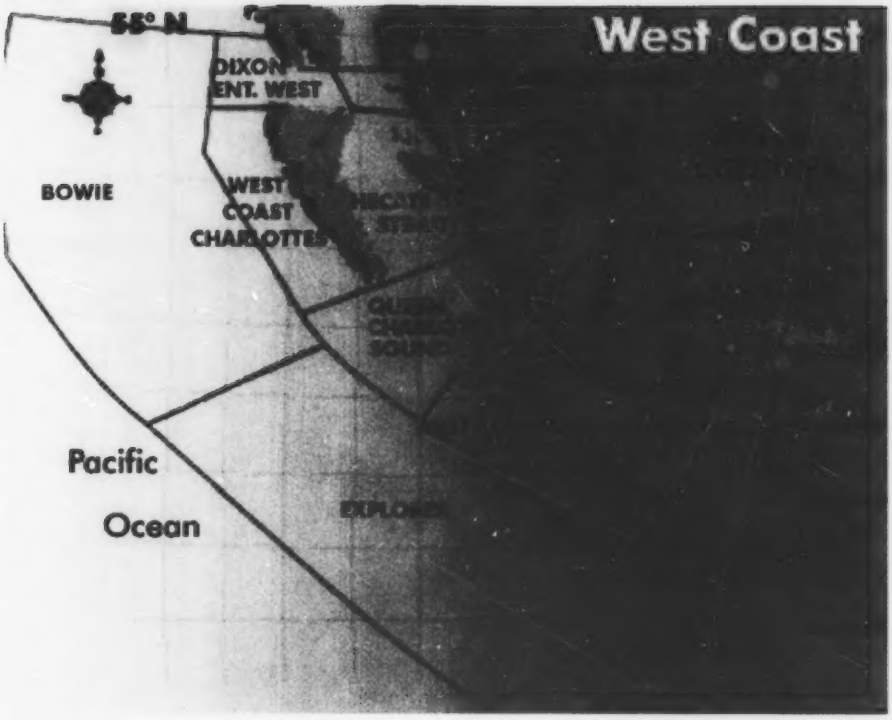


Figure 4.6 Weather forecast areas for British Columbia marine waters.

Forecast:

Storm warning continued.

Winds northeasterly 5 to 15 knots veering to southeast 20 this evening and rising gales 35 overnight. Winds rising to southeast gales 40 to storm force 50 Monday morning then easing to southerly 25 late Monday afternoon. Cloudy. Rain Monday. Seas near one metre building to 2 to 3 metres tonight and to 4 to 6 metres Monday morning.
Outlook. Strong to gale force southerlies veering to strong westerly.

In addition to the regularly-scheduled marine forecasts, special marine weather warnings or weather advisories are issued as required:

STORM WARNING

STORM WARNING ISSUED FOR THE COASTAL WATERS OF BRITISH COLUMBIA BY THE PACIFIC WEATHER CENTRE OF ENVIRONMENT CANADA AT 8:49 PM PDT SUNDAY 14 OCTOBER 2001.

STORM WARNING ISSUED FOR BOWIE.

A 977 MILLIBAR LOW WILL MOVE ACROSS THE WESTERN SECTIONS OF THE BOWIE REGION ON MONDAY. WESTERLY STORM FORCE WINDS OF 50 TO 55 KNOTS ARE EXPECTED TO DEVELOP LATE MONDAY AFTERNOON AND EVENING AFTER LOW HAS PASSED.

FURTHER DETAILS FOLLOW IN THE NEXT REGULAR MARINE FORECAST AT 9:30 PM PDT.

The marine forecast desk is primarily served by a network of marine weather reporting stations and buoys (Figure 4.5). *The stations report their parameters* (Table 4.2) *via satellite on an one hour basis, with observations being distributed to the AES observation network for application in numerical forecasts and as guidance information for the marine forecast desk.*

Marine observations (e.g., wind and sea state) are also reported to the observation network by ships of opportunity traveling through the region. These observations are rarely continuous for more than a few days and the geographic areas that they cover along the coast are somewhat random. Wind and wave observations from ships of opportunity are less accurate than buoy measurements, and are used in a qualitative manner by the forecast desk. However, ships of opportunity do report accurate measurements of atmospheric pressure; these pressure readings serve an important role as early-warning indicators for "marine bomb" events. Observations from ships of opportunity are reported every 6 hours.

Wind forecasts are prepared by Canadian Meteorological Centre (CMC) in Montreal using a numerical wind-prediction model *driven by the network of observations and surface analysis charts. Surface winds are supplied to* a *numerical wave forecasting computer model at CMC which is run twice a day and provides forecasts up to 48 hours. The* wave-forecasting *model uses a coarse grid with resolution on the order of 80 to 100 km.* This grid spacing has been found to be too coarse to fully resolve wave conditions during intense storm events.

The CMC forecast information is used as guidance by the marine forecast desk to produce their own subjective forecasts. Typically, the marine forecaster will modify the CMC forecasts based upon the specific marine regions, the latest observations, and their wave forecasting experience. Thus, the forecasting procedure represents a combination of data-driven numerical modelling coupled with interpretation and adjustment by experienced meteorologists.

In the early 1990's the forecast unit followed a "marine bomb" checklist to minimize the chance of these weather systems developing unnoticed. However, shortly after, the official *checklist was eliminated: the sophistication of the numerical forecast models and the increased experience of the forecasters made this task unnecessary. Weather system information is now well managed and rarely does a storm go undetected.*

Weather forecasts are currently verified through comparison with observed winds at two stations in the West Coast Vancouver Island North forecast area (Figure 4.6): Sartine Island and Solander Island. A

statistically-rigorous procedure is used to assess forecast accuracy, with results reported for each month of the year. *The marine forecast unit indicates that it can adequately predict gale force and stronger events with a six hour or better notice time. Existing wave forecasts are believed to be accurate to within 0.5 to 1.0 m.*

Additional forecasting tools at the disposal of the marine forecasting desk include the Forecast Production Assistant, also known as the Pacific Wave Forecasting System (PWF). *The* PWF *includes an embedded wave model and allows the forecaster to adjust surface pressures as input to the model to allow better wind forecasts and more accurate hindcasts for specific forecast areas of interest. Generally, this is a tool that would be applied* in hindcast mode *for specific customers (e.g. offshore operators, or ships with specific vessel routing requirements) and is not used for* routine weather forecasts.

The marine forecast unit maintains good cooperative working relationships with the United States Weather Centre offices in Juneau, Alaska which results in shared information and mutual benefit to the forecast user communities along the British Columbia coast.

4.5 Gas Hydrates

Gas hydrates are solid forms of the commonly occurring gases in offshore sediments. Marine gas hydrates form in locations where the temperature and pressure regimes are sufficient to maintain the solid phase; on the western Canadian continental margin, hydrates are found below a water depth of approximately 800 m (David Mosher, pers. comm.). Gas hydrates are relatively abundant in offshore areas, having been retrieved by bottom draggers on numerous occasions.

Hydrates are typically identified on seismic profiles as bottom-simulating reflectors (BSRs). BSRs are evident on about half of the mid-continental slope; extensive research was conducted on one hydrate deposit through Leg 146 of the Ocean Drilling Program (Hyndman et al. 2001).

Gas hydrates pose some hazards to exploratory drilling operations. The drilling itself may cause dissociation of the solid phase, increasing the free gas content in the bottom sediments and potentially leading to decreases in sediment strength and slope stability. However, gas hydrates are a common occurrence in other waters where hydrocarbon exploration and development activities are ongoing, and there exists considerable experience in dealing with the potential hazards. In addition to posing a potential hazard to drilling activities, hydrates are seen as an undeveloped resource to be exploited in the future as the appropriate technologies are developed.

4.6 Faulting and Earthquakes

The area around the Queen Charlotte Islands, Dixon Entrance, Hecate Strait and Queen Charlotte Sound is known to be one of the most seismically active areas of the world. However, as discussed later in

Section 5, many existing offshore oil and gas developments have been designed for similar seismic activity.

Among the most important seismo-tectonic features in this area is the northwest trending Queen Charlotte Fault (QCF) that forms the transform boundary between the North American Plate to the east and the Pacific Plate to the west (Figure 4.7). The QCF lies within 10 to 20 km (6 to 12 miles) off the west coast of the Queen Charlottes Island and transects the northern portion of the Petro-Canada lease area. Several large earthquakes have been ascribed to the movements along the QCF with a 1949 earthquake of Magnitude 8.1 (M8.1) and a few other events exceeding M7. The 1949 M8.1 event was triggered by a fault break several hundred kilometres long and resulted in a fault displacement of about 8 m (26 feet). The most recent one of these events was the M7.4 earthquake that occurred in 1974 near the southern tip of the Queen Charlottes Islands. Another M8.2 event occurred on the northward extension of the QCF along a segment known as the Fairweather Fault in Yakutat Bay, Alaska in 1899.

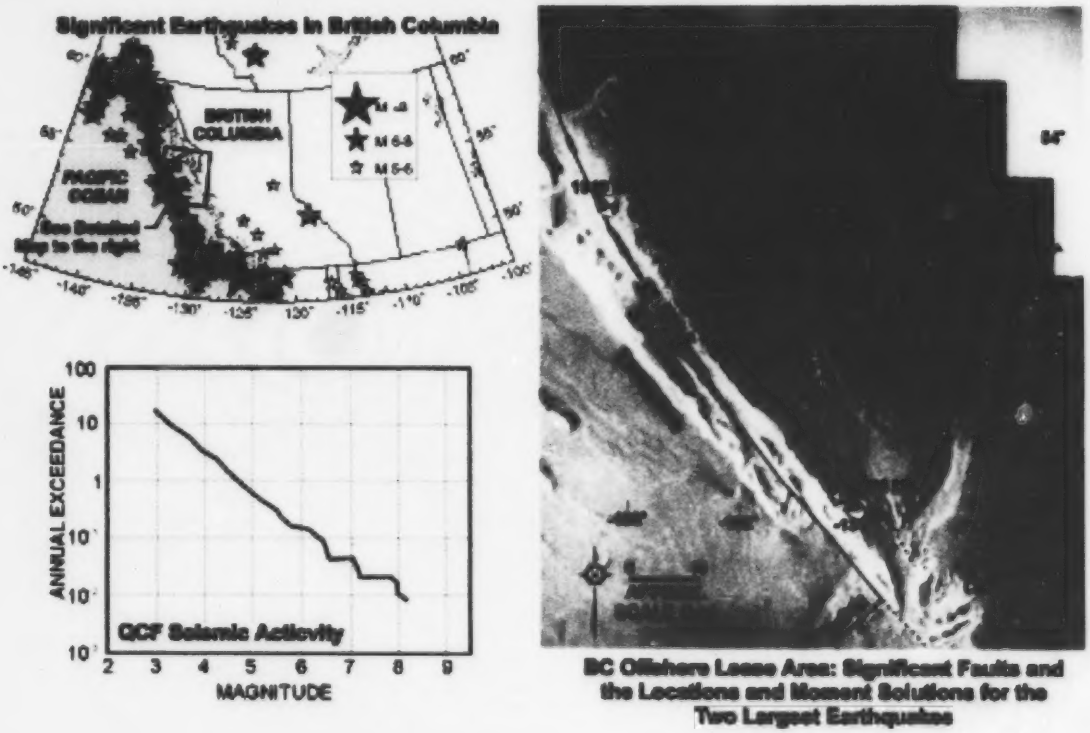

Significant Earthquakes in British Columbia
BRITISH COLUMBIA
PACIFIC OCEAN
M 6-6
M 5-6
ANNUAL EXCEEDANCE
MAGNITUDE
QCF Seismic Activity
BC Offshore Lease Area: Significant Faults and the Locations and Moment Solutions for the Two Largest Earthquakes

Figure 4.7 Seismicity and Faulting around the Queen Charlotte Islands

The Yakutat Bay earthquake was triggered by a several hundred kilometres long fault break and resulted in a displacement of 15 m (49 feet). Such an earthquake is expected to occur within 3 to 15 km (2 to 9 miles) below seafloor. Several other shallow, northwest trending faults cross the Queen Charlottes Islands. Some of these faults have been identified from the seismic data obtained during the earlier offshore oil and gas Exploration and Production (E&P) activities in this area and the geophysical survey

of the Geological Survey of Canada (Rohr and Dietrich 1990; 1991). From west to east, most notable ones are the Rennel Sound Fault and the Sandspit Fault. The Rennel Sound Fault follows the centre of Moresby Island. The Sandspit Fault begins from the northeastern portion of Moresby Island south of Sandspit and appears to continue to north central Graham Island. It has been hypothesized that the cluster of seismic activity in the north central Graham Island is ascribable to the Sandspit Fault, although it is possible that these activities are due to deeper faults that are yet to be identified. Another fault has been proposed in east central Hecate Strait based on seismic data (Rohr and Dietrich 1990), the northern portion which also appears to be seismically (earthquake) active. The historical earthquake data and the length of fault trace indicate that seismicity along the QCF is capable of generating an earthquake between M8.5 and M9.0 (see, e.g., Slemmons and McKinney 1977). M7 earthquakes are likely to occur within 3 to 15 km (2 to 9 miles) below seafloor along other active faults west of QCF.

When assessing the potential impact of faults and fault movements on the location and design of offshore oil and gas facilities, it is necessary to estimate the relative age of fault or time since the last apparent movements or displacements along the fault. For designing structures it is considered appropriate to assess the likelihood of movements since the last ice age, i.e., within the past 12,000 years. Faults that could have moved since then are deemed potentially active. As discussed in later sections, investigations would be undertaken to identify and avoid the locations of potentially active faults for locating offshore oil and gas facilities.

4.6.1 Accelerations and Ground Motion

The results of probabilistic seismic hazard analysis presented by CGS (1992) indicates that the 1 in 475 year earthquake peak horizontal acceleration (PHA) west of central Hecate Strait and north central Graham Island is between 0.32 and 0.4 times the acceleration due to gravity (g). The corresponding peak ground velocity (PGV) is between 0.32 and 0.4 m/s (12.6 to 15.7 foot per second). Further east, the PHA for 1 in 475 year earthquake decreases to 0.12g along the eastern shoreline of Hecate Strait and the corresponding PGV is 0.24 m/s (9.4 foot per second).

The historical seismicity in this area was re-examined in connection with the recent proposal of changing the seismic design basis in the Canadian National Building Code from 1 in 475 earthquake to 1 in 2,500 year (Adams, Halchuk and Weichart 2000). These results indicate that in the onshore areas of the Queen Charlotte Island and its immediate offshore vicinity, a 1 in 2,500 year event would lead to a PGA between 0.8g and 1.2g. In north central Hecate Strait the corresponding PGA is between 0.4g and 0.6g, while in the remainder of the lease areas are likely to experience a PGA between 0.16g to 0.40g.

The commonly used code of practice for designing fixed offshore platforms, API RP 2A, has in-built earthquake design procedures that account for the level of ground motion in US offshore areas. These procedures can be readily modified to account for the anticipated ground motions in British Columbia offshore.

4.6.2 Tsunamis

Tsunamis or sea waves are generated by sudden vertical motion of the seafloor resulting from an earthquake or a submarine landslide. The seismo-tectonic regime in the vicinity of Dixon Entrance, Hecate Strait and Queen Charlotte Sound is dominated by strike-slip mechanism and is thus not perceived as particularly tsunamigenic. However, the seismic activities are likely to cause landslides, which in turn may trigger tsunamis. Tsunamis generated by distant subduction earthquakes may also affect this area. Tsunami waves travel at velocities of several hundred kilometres per hour and affect areas several thousand kilometres away. The tsunamis from the Aleutian Islands are therefore likely to reach the areas off the Queen Charlotte Islands within minutes after the trigger. These events are therefore also of concern in the design of offshore oil and gas facilities around the Queen Charlotte Islands. Areas most vulnerable are adjacent to steep onshore bluffs, submarine slopes, and enclosed basins. Several tsunamis have been reported in the coastal areas of British Columbia and Alaska Panhandle. Most significant among these was the tsunami generated during a 1958 earthquake on the Fairweather Fault. A large landslide triggered during this event crashed into Lituya Bay generating 30 m (100 feet) waves that stripped trees to 520 m (1700 feet) elevation on the opposite shoreline. A non earthquake-related submarine landslide destroyed a part of Skagway Harbour in Alaska in November 1994.

Satake (2001) reports an analytical study of tsunami in the Pacific Rim triggered by a large landslide in the Hawaiian Islands and estimated that the tsunami height could be 30 m (100 feet) in the western margins of Dixon Entrance and Queen Charlotte Sound. Lynett *et al.* (2001) also proposed a numerical model for tsunamis. The site-specific tsunami-related design parameters including wave heights and run-up can be estimated for the oil and gas developments in British Columbia offshore lease areas following such procedures. These parameters should then be used in structural design and risk management of offshore oil and gas facilities.

4.7 Fault Movement, Slope Stability and Liquefaction Potential

Among the significant geotechnical issues for the design of offshore oil and gas facilities are fault movement, submarine slope stability and liquefaction potential. For managing these risks, the areas of potential instability are first identified from shallow geophysical, bathymetric and oceanographic surveys so that the facilities can be located in lower risk areas. It is difficult to estimate ground movements for fault break, slope instability and liquefaction using rigorous analytical procedures. Worldwide experience and empirical methods are usually relied on for estimating the effects of these instabilities. For instance, a conservative (upper bound) magnitude of fault movement can be estimated using empirical relationships based on observations (e.g., Wells and Coppersmith 1994). The ground movements due to potential slope instability and liquefaction are similarly estimated for a trigger (e.g., an earthquake) with a large return period (typically 1,000 year) using soil strengths from geotechnical testing and following empirical procedures such as Hynes-Griffin and Franklin (1984), and Youd and Idriss (1996). Where appropriate, more sophisticated finite element computer models can be used to

predict soil movements and the impact on facilities. The offshore oil and gas facilities should be designed for these low-likelihood ground movements.

Shallow faults and the extent of deformation of unlithified seafloor sediments are often identifiable from careful interpretation of high resolution seismic survey data. In certain conditions, the deformation of the sediments overlying shallow faults is inferred to be due to fault movements or creep and the underlying fault is deemed as potentially active. Bathymetric surveys can look for topographic patterns associated with slope instability. Such signatures of slope instability include toe-bulge, hummocky seafloor and talus heaps near the foot of steep submarine slopes. The presence of gas in seafloor sediments can often be identified from the high resolution seismic survey because gassy sediments absorb a significant portion of the seismic energy and wipes out the reflections from underlying layers. In some areas of British Columbia offshore gassy sediments are known to be associated with slope instability.

After completion of a detailed geophysical survey, areas of potential soil instability can be further investigated using geotechnical in-situ testing tools and sampling procedures. These investigations typically involve piezocone penetration testing (CPT), pressuremeter testing (PMT) and drilling and soil sampling. Laboratory tests are carried out on recovered samples to estimate soil strength and other engineering properties. The objective of the geotechnical investigation is to estimate the shear strength of the soil, based on which the possible soil stability can be assessed. These issues are discussed in more detail in Section 5.

4.8 Summary

In summary, the northern waters of British Columbia present a complex physical environment, with highly variable bathymetry, strong winds and currents, and high waves during storm events. The region is also one of high seismic activity, with the associated risk of slope failure and tsunami generation. Conversely, the significant risk to offshore facilities posed by icebergs on the Grand Banks of Newfoundland is not found on the west coast of Canada.

The extent of our knowledge of the physical characteristics of the west coast marine environment varies, depending on the physical aspect under consideration, and is highly dependent on the extent of previous regional data collection efforts. In general, our current state of knowledge regarding the physical environment of these waters has improved significantly since the 1986 report of the WCOEEAP.

Although the physical characteristics of the northern waters are relatively complex and there are areas where our knowledge base needs improvement, the technologies to do so are readily available and need only the dedication of sufficient resources to the task. In other jurisdictions such as the east coast of Canada, the collection of the required data has proceeded through the combined efforts of government and industry as offshore activities proceeded from the planning through the implementation stages.

The physical conditions under which offshore hydrocarbon exploration, development and production activities occur impact engineering designs, operational procedures and environmental impacts associated with any contaminant releases to the marine environment. Uncertainties in the physical parameters discussed in this section can be dealt with through standard approaches such as increased factors of safety included in engineering designs and operational procedures, while environmental concerns can be reduced through the incorporation of additional spill prevention measures into offshore equipment. The net effect of high uncertainties in the physical conditions under which offshore activities are to occur is to increase the cost of offshore activities and reduce the economic feasibility of a given project, rather than to limit the technical feasibility of offshore exploration.

5.0 ENGINEERING

The objective of this section is to review the significant engineering issues that impact the economics and safety of exploration and development activities for the offshore oil and gas industry. The focus of the following sub-sections is on recent technological advances and operational procedures, particularly those relevant to British Columbia offshore areas. Advances in the areas of safety and risk management have been outlined. The performance of existing offshore structures under severe seismic and climatic conditions is also reviewed to qualitatively assess the reliability of the current state-of-practice in the offshore oil and gas industry.

There are five sequential phases in a typical offshore oil and gas development:

- seismic and geophysical surveys;
- exploration;
- development;
- production; and
- decommissioning.

Important engineering and technological aspects of each of these phases, as well as the performance and risk associated with these activities, are discussed in the following sections.

5.1 Seismic and Geophysical Surveys

The initial geophysical surveys are undertaken to provide a three-dimensional (3-D) image of subsurface geological structures. The seismic surveys are primarily used to identify the "areas of closure," which sometimes act as hydrocarbon traps. The feasibility of exploratory holes depends on the size of these hydrocarbon traps. Seismic surveys must be properly planned and designed in relation to the geology of the study area. They are seldom effective in the first attempt and several surveys may be needed for achieving the necessary definition and confidence. The initial seismic surveys are also used to estimate the fluid pressure in the formations and to identify the presence of gas, although it is not possible to

distinguish gaseous hydrocarbons from other naturally occurring gases such as carbon dioxide or nitrogen. Enhanced accuracy of seismic surveys and innovative use of these data have increased the success ratio of offshore oil and gas exploration drilling and reduced the cost of these operations and their environmental impact.

Seismic surveys involve measurements of travel times of reflected or refracted seismic waves. The interpretation of seismic data requires assumptions regarding the transmission characteristics of the geologic units. Therefore interpretation of seismic data requires judgement and experience. Until drill holes are completed to confirm the subsurface conditions the inference from seismic surveys only provide indications of probable conditions.

Further geophysical surveys are undertaken before, during and after exploratory drilling. These surveys include gravity and geomagentic surveys, shallow seismic surveys and other seabed mapping surveys for detailed geological hazard assessment. Additional geophysical measurements are carried out during exploratory drilling (Measurement While Drilling or MWD) to assess the formation pressures and porosity.

The developments in information technology and communication have resulted in utilization of broad-band seismic data, and a significant reduction in turn-around time between generation and analysis of geophysical data, leading to virtually real-time project management for an exploratory drilling program. This, in turn, has greatly reduced the risks of borehole instability and blowout and consequent occupational hazard and environmental impacts.

5.1.1 Seismic Survey

A conventional 2-D seismic survey involves towing the arrays of source and receivers from a survey vessel in a single row. An acoustic wave is generated from the source and the arrival of the wave reflected or refracted from the boundaries between different geologic units is recorded. Air Guns are often used to generate acoustic waves and hydrophones to record the reflected or refracted waves. A typical surveying program would include several such recordings along parallel survey lines spaced 0.5 to 1 km (0.3 to 0.6 mile) apart, usually in two orthogonal directions. The appropriate orientation of these lines requires a good understanding of the geologic structure within the study area. These surveys are undertaken under favourable weather conditions so that the quality of sound recording is acceptable.

From the interpretation of 2-D seismic survey data, the subsurface structure of a vertical slice is deduced and the slices from individual survey lines are treated as stand-alone results. Subsequent interpretation involves identification of geological relationship between neighbouring vertical slices to develop a 3-D subsurface map. The quality of a 2-D seismic interpretation depends on the experience and insight of the geophysicist into the acoustic characteristics of the geologic material being surveyed.

Since 1975, 3-D recording and interpretation techniques have become available involving simultaneous

recording of reflected acoustic waves by a set of parallel arrays of hydrophones. A 3-D survey provides a significantly greater amount of information for survey grids (instead of survey lines of a 2-D survey) that may be spaced as closely as 100 m (330 feet) apart. Improved computer capabilities allows for the rapid analyses and interpretation of the vast amount of information generated in a 3-D seismic survey. This advance has resulted in more reliable and detailed subsurface imaging and an improved prediction of drilling results. Initially 3-D survey was utilized solely for oil or gas field development optimization but in the past ten years has become a valuable exploration tool to identify smaller exploration targets.

The latest development is the 4-D or time-lapse measurement, where recording devices are buried in the seafloor over an oil field. This technique is mainly utilized in reservoir management and to assist in the judicious drilling of late field life development wells to maximize recovery.

Air Guns primarily generate compression waves (p-wave) by blowing a compressed air pulse into seawater. The array of source and recorders are towed by the survey vessel in a single row in a 2 dimensional (2-D) survey, or in multiple rows in a 3-D survey. A portion of the seismic energy generated by the air guns gets converted into shear waves (s-waves) at the water-soil interface. Since water cannot transmit shear wave, the reflection pattern of s-waves cannot be measured with a receiver array towed above seafloor. The subsurface information contained in the s-waves is, therefore, lost in a conventional seismic survey. Use of multi-element geophones placed at the seafloor for recording the s-waves has also begun in recent years to utilize the information (Huffman and Castagna, 2001).

5.1.2 Supplementary Geophysical Information

Supplementary geophysical data are obtained from gravity and geomagnetic surveys. The gravity and magnetic surveys allow identification of "anomalies" or variations from regional averages and subsequently improve the 3-D picture of a sedimentary basin. These are relatively inexpensive compared to seismic surveys and the measurements are sometimes utilized in converting seismic travel times to depths. Modern high-resolution aero-margnetic surveys are flown from specially equipped aircraft at 60 to 90 m (200 to 300 feet) altitude and can provide details such as fault trace and near surface volcanic rock.

Additional data are collected during drilling (*i.e.*, Measurement While Drilling or MWD), which include vertical seismic profiling, magnetic resonant imaging (MRI), gravity and resistivity measurements. The first MWD tools went in service in 1978. Neutron Porosity Measurement capability was added to these tools in 1987, geo-steering and pressure detection capabilities in 1993 and MRI in 1997. These tools can now operate over broader pressure and temperature ranges and in various chemical environments. For instance, resistivity devices are available for use in water- oil- and synthetic- based drilling muds. MWD is also extensively used for controlling hole trajectory and steering in multilateral and horizontal directional drilling.

5.1.3 Seabed Mapping Technologies

The geophysical survey techniques described above are used primarily to map deep subsurface structures with the intent of identifying hydrocarbon reservoir rocks and the associated trapping structures. Additional information is needed on sea floor and shallow subsurface geology, seabed geotechnical properties and morphology for the following objectives:

- to optimize the design of the subsurface seismic survey program and to aid in interpretation of survey results;
- to assess regional and site-specific geohazards;
- to optimize the selection of drilling rigs and placement of drill holes;
- to define design parameters for sea floor installations;
- to assess the environmental impacts of exploration and subsequent phases of offshore oil and gas activities (development, production and decommissioning).

In this section, the technologies currently used to map and interpret the features and characteristics of the sea floor and shallow subsurface are summarized. These techniques include swath or multibeam bathymetry, sidescan sonar, acoustic seabed classification, high resolution seismic reflection profiling, visual observations, seabed sampling, laboratory testing and in situ measurements of geotechnical parameters.

5.1.3.1 Navigation and Positioning

An integral part of any seabed mapping or sampling procedure is accurate positioning. Historically, LORAN C was the most commonly used navigational method for regional surveys in Western Canadian waters. The accuracy of the LORAN C system varies with location, depending on position relative to the fixed base stations. In the Queen Charlotte and Hecate Basins, positional error based on LORAN C can be up to one nautical mile (Vaughn Barrie, pers. comm.).

In recent years, access to the satellite-based Global Positioning System (GPS) has become essentially universal. The Global Positioning System was originally designed for the U.S. military and is funded and controlled by the U.S. Department of Defense (DOD). The system consists of a set of 24 or more satellites that each orbit the earth once every 12 hours. Signals from at least four individual satellites are required in order to calculate position in three dimensions together with an accurate time signal. Signal access is available to civilian users world-wide with the use of a GPS receiver (Dana 2000).

Prior to May 2000, signal accuracy for non-military users was intentionally degraded by the DOD through the implementation of selective availability, a time-varying bias in the satellite signals. However, post-processing of the data using differential methods relative to fixed base stations allowed higher levels of accuracy to be achieved. In the early 1990's, the Canadian Coast Guard installed a network of differential base stations at British Columbia lighthouses. In the United States, the Federal

Aviation Agency has established the Wide Area Augmentation System (WAAS), blanketing North America with a differential signal available to most new "high-end" GPS receivers (http://gps.faa.gov/Programs/WAAS/waas.htm).

Since May 2000, selective availability has been turned off, allowing general access to the non-degraded signal. Current levels of accuracy for GPS are on the order of 100 m in horizontal position for basic readings from the GPS satellite system, with accuracy on the order of several metres using the differential system. Differential carrier-phase tracking with Real Time Kinematic (RTK) processing, although not yet in common use, achieves centimetre-level accuracy in both horizontal and vertical position for a moving remote receiver (Dana 2000; GeoAcoustics Ltd. 2000).

As a result of the accuracy of the currently-available navigation and positioning systems, subsea data can be accurately located, improving our ability to locate facilities away from hazardous areas and assisting in engineering evaluations to design for hazards.

5.1.3.2 Swath Bathymetry

Perhaps the most significant recent advancement in seabed mapping technologies has been the widespread adoption of swath bathymetry techniques for both precise water depth measurement and mapping of sea floor morphological features. A swath bathymetry system uses high frequency acoustic pulses generated by hull-mounted transducers to measure travel time between the ship and the sea floor. While a single beam echosounder obtains a single depth measurement under the survey vessel for each acoustic "ping", swath systems obtain many measurements across a transect perpendicular to the ship's path.

Many different types of systems and methods are available for swath bathymetric measurements. These include multibeam systems consisting of an array of individual narrow-beam transducers, mechanical or electronic scanning of a single beam, electronic beamforming systems and phase comparison techniques. Although many different types of systems are available, all essentially measure discrete reflections from small patches of sea floor. The term multibeam bathymetry is often used interchangeably with swath bathymetry to describe the general technique, rather than to identify a particular type of system.
The widespread application of swath bathymetric survey techniques has been facilitated by the combination of accurate navigation through GPS, high-speed digital data acquisition systems and advancements in both transducer technology and digital data processing techniques. With achievable swath widths on the order of five to ten times water depth, high-resolution bathymetric maps with complete coverage of the sea floor can be readily developed. Although survey resolution and accuracy are functions of water depth, ship speed and system configuration, typical values would be on the order of a few metres horizontal resolution and centimetres in vertical accuracy in shallower waters (David Mosher, pers. comm.). An example of a bathymetric map generated from a multibeam system is shown in Figure 5.1.

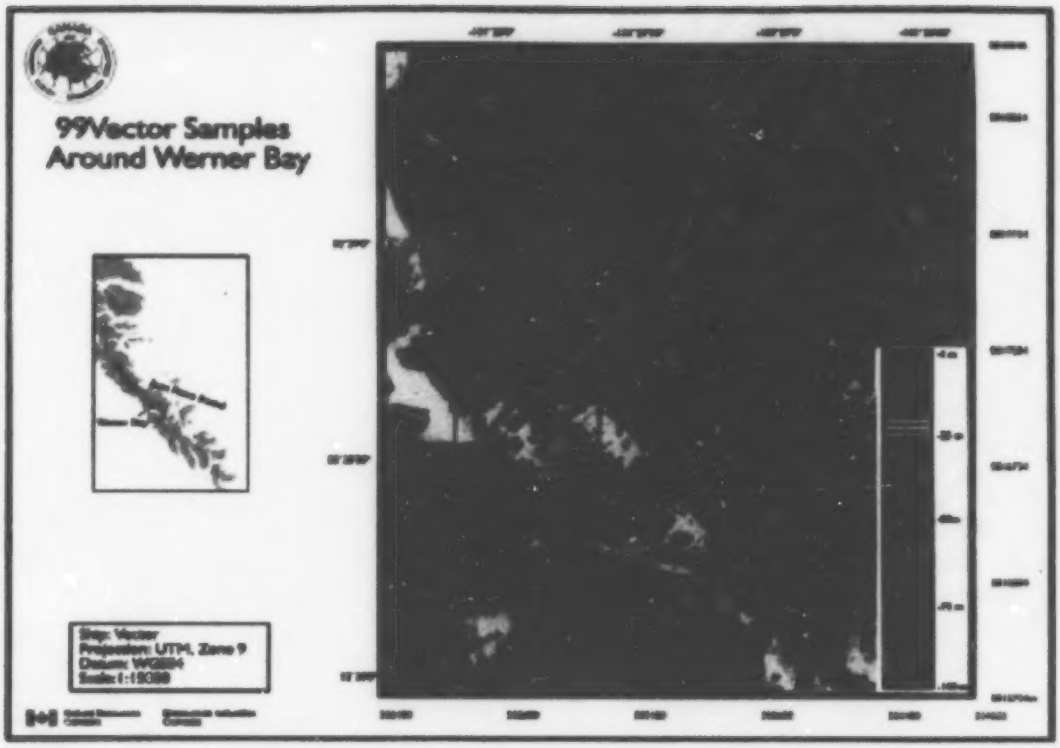


Figure 5.1 **Colour-banded bathymetric map developed from multibeam data collected near Werner Bay, Queen Charlotte Islands (from Josenhans and Harding 1999)**

In addition to accurate mapping of bathymetry, swath systems have provided valuable information for the mapping and interpretation of surficial morphological features, and for the accurate assessment of submarine slope stability. Figure 5.2 shows an example of multibeam data collected off Mapleguard Spit, on the east coast of Vancouver Island. In the top image, bathymetric data have been presented in a sun-illuminated format, highlighting bottom morphology. The middle image shows slope angle in a plan-view format, while the bottom image shows the depth profile along a selected cross-shore transect. Backscatter data, although not shown in Figure 5.2, can also be used to aid in interpretation of seabed texture and surficial morphology.

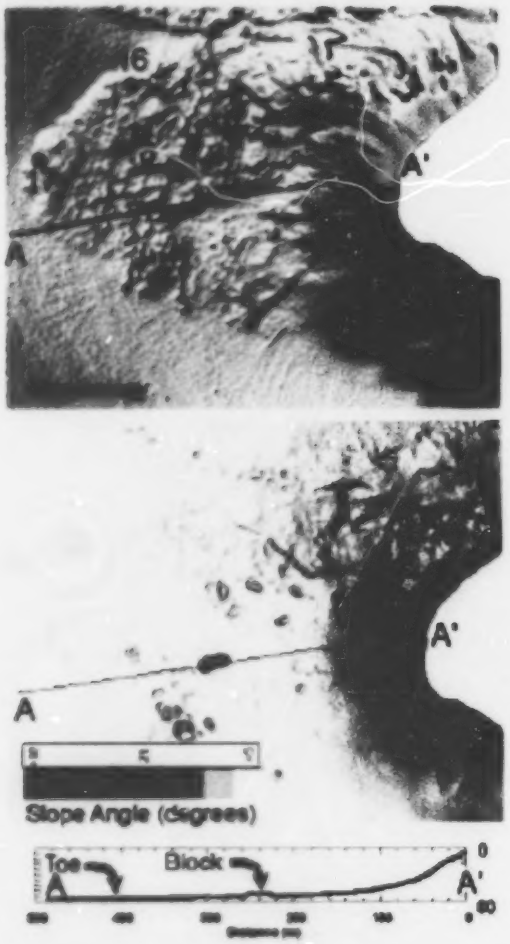


Figure 5.2 Morphology (top) and slope angle (middle) images and depth profile (bottom) of the southern failure lobe at Mapleguard Spit on Vancouver Island. The profile is at a 1:1 scale (from Mosher et al. 2001).

5.1.3.3 Sidescan Sonar

Sidescan sonar systems have long been the traditional method for imaging the sea floor for purposes of surficial morphological assessment. A sidescan sonar uses a wide-angle beam to measure the acoustic reflectivity of the sea floor, providing information on surficial texture in addition to morphology. Sidescan systems are typically towed in a "fish" close to the seabed in order to enhance the measurement of sea floor reflectivity. As a consequence of this operational configuration and the available data processing methods, sidescan systems do not give accurate bathymetric information. However, horizontal resolution is much higher than for a multibeam system, allowing better resolution of seabed morphology (Philip Hill, pers. comm.).

Although the basic technology behind these systems has remained unchanged in recent years,

improvements in transducers and system electronics have led to significant increases in signal quality. In addition, digital systems and sophisticated post-processing software packages are now available, greatly improving the ease with which scale-corrected mosaics of the sea floor can be developed. Figure 5.3 shows a sidescan sonar mosaic of the area near Grief Point, on the east coast of the Strait of Georgia.

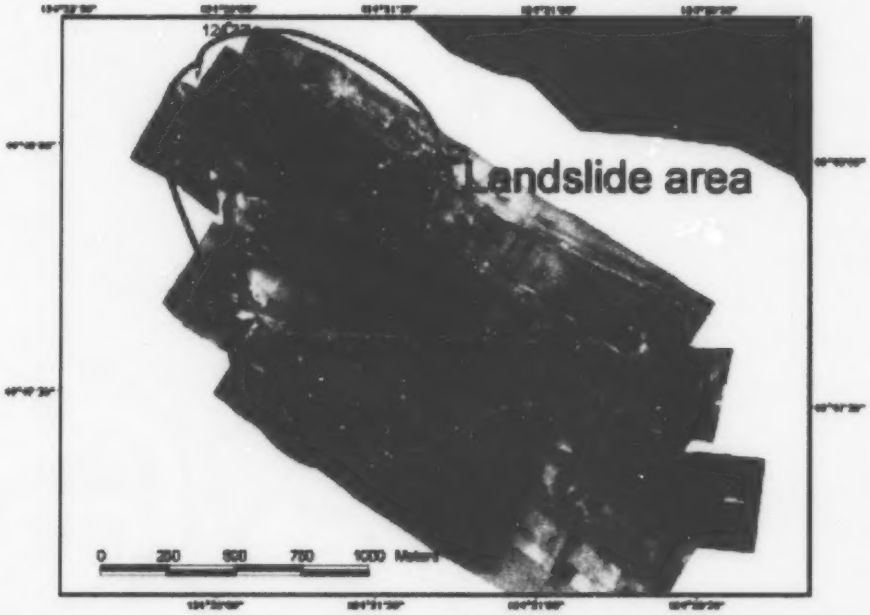


Figure 5.3 Sidescan sonar mosaic of the Grief Point landslide. Water depths range from 20 m in the north to 220 m in the southwest area of the image (from Mosher et al. 2001).

Recent efforts have focused on the development of interferometric systems, which use phase comparison between two or more vertically-spaced receiving elements in the sonar transducer to produce swath bathymetric measurements. Given the similarity between these systems and side scan sonar arrays, signal output can also be presented in a manner similar to a sidescan sonogram (GeoAcoustics 2000; Geen 1999).

5.1.3.4 Acoustic Seabed Classification

Both sidescan sonar and multibeam bathymetry systems provide measurements of acoustic backscatter, or seabed reflectivity. Measurements are displayed as two-dimensional images, or sonograms, of the sea floor. The sonograms are then visually interpreted by an experienced marine geoscientist in order to determine the material composition of the seabed (e.g. soft mud, sand and gravel, bedrock, etc.) and the nature of sea floor morphological features. The process is extremely qualitative and relies heavily on the expertise of individual interpreters.

In recent years, quantitative methods have been developed to characterize the composition and

complexity of the seabed based on measured properties of the acoustic return signal from existing bathymetric and sidescan sonar systems. Pioneered for use with single-beam echosounders, acoustic seabed classification systems analyze a suite of characteristics of the return signal to statistically group the surveyed seabed into a number of distinct classes. Each class represents a unique combination of physical and biological characteristics. Maps of the survey area can then be developed showing the spatial extent of each class, representing the acoustic diversity of the sea floor. An example is shown in Figure 5.4, for the Race Rocks Marine Protected Area to the west of Victoria, BC.

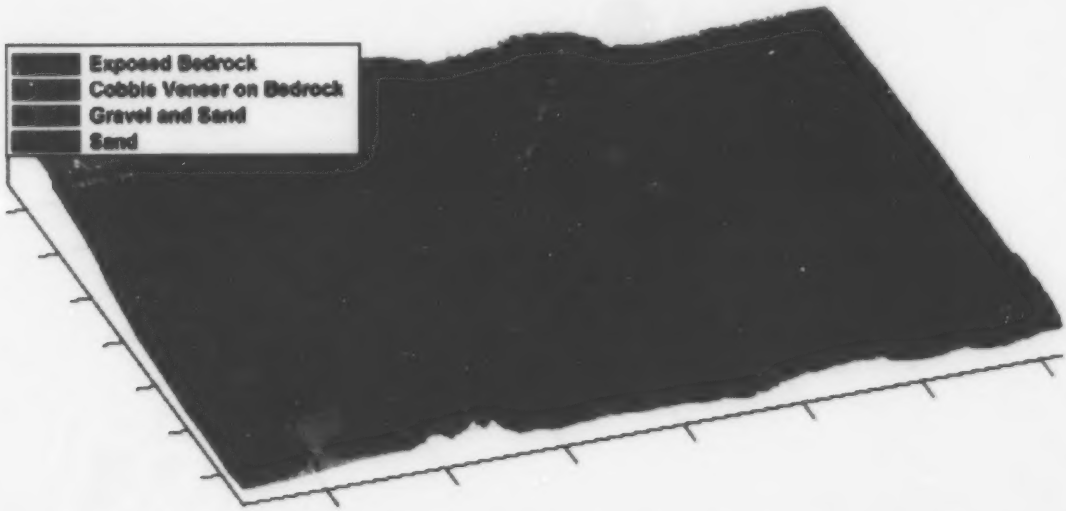


Figure 5.4 Multibeam bathymetry and acoustic seabed classification from single beam echosounder for Race Rocks, British Columbia (from Quester Tangent Corporation 2000).

While acoustic seabed classification systems do not directly measure traditional index properties of the seabed (e.g. sediment grain size, bulk density, etc.) or morphological characteristics (e.g. bedform height and spacing), changes in acoustic class do represent changes in the combination of these and other parameters. As for other mapping tools, ground-truthing is required.

Seabed classification has received recognition as a habitat mapping tool (Smity *et al.* 2001), and can be used as a preliminary survey tool to select sites for in situ seabed investigations. Acoustic seabed classification has been accepted as a reliable method for mapping seabed diversity by the scientific community, and the Canadian Hydrographic Service has proposed that it become a component of operational hydrography. Acoustic classification is only now being adopted for commercial applications (Bill Collins, pers. comm.). Ongoing research into acoustic seabed classification is being conducted through the Canadian Acoustic Remote Sensing Facility (C-MARS) at the University of Victoria (http://www.c-mars.ca).

5.1.3.5 High Resolution Seismic Profiling

Multibeam and sidescan sonar systems give two-dimensional, plan views of the sea floor. High resolution seismic profiling methods are used to view the seabed as two-dimensional, vertical slices, allowing subsurface definition of features such as faults, historic failure surfaces, subbottom horizons and gas-charged zones. These methods use low-frequency acoustic signals from a variety of source types (pingers, boomers, sparkers, airguns and water guns), so as to allow signal penetration into the seabed. Changes in acoustic impedance within the seabed cause partial reflection of the signal back to the source, allowing depth below the seabed of the reflecting surfaces to be calculated. High resolution seismic profiling methods typically use higher frequencies than those used in deep seismic work (Section 5.1.1), permitting the near-surface seabed structure to be mapped in greater detail, but reducing the extent of signal penetration into the seabed (see Terra Remote Sensing Inc. 1999 for a more detailed description).

As for sidescan sonar systems, the basic technology behind these systems has remained relatively unchanged in recent years. The major advancements have been in the digital processing and post-processing of the signal, allowing for easier interpretation of reflectors and sub-bottom features. Figure 5.5 shows a high resolution seismic profile (Huntec Deep Tow System) transecting the landslide deposit shown in Figure 5.3.

Towed three-dimensional sensor arrays are not used in high resolution seismic profiling, since the required sensor spacing, as determined by the signal frequency, is not generally achievable under marine conditions. The use of geophones placed at the sea floor to measure shear waves is a topic of current research (Philip Hill, pers. comm.).

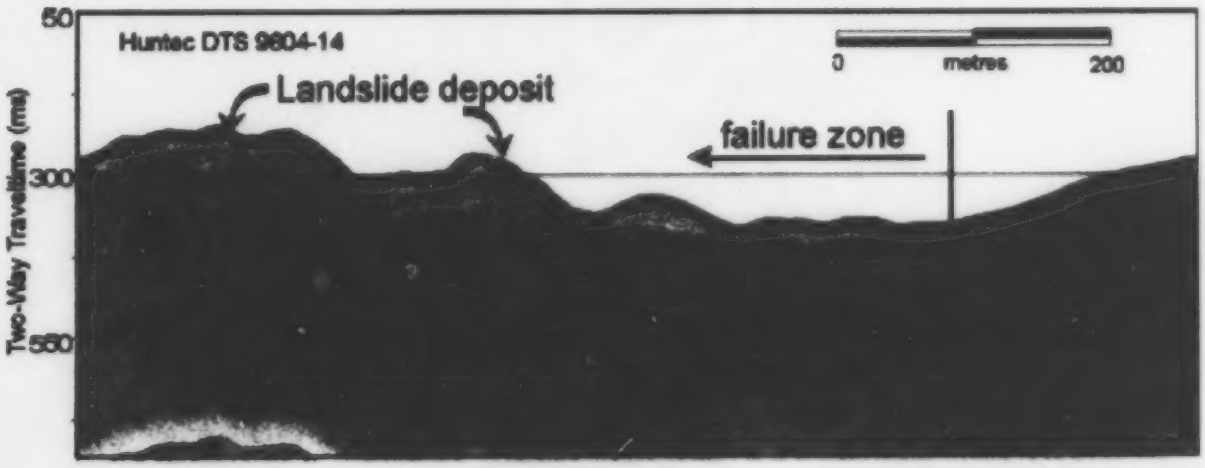


Figure 5.5 High resolution seismic reflection profile crossing the Grief Point submarine landslide.

5.1.3.6 Visual Observations

Visual observations of the seabed are invaluable for a number of uses, including the ground-truthing of geophysical survey information, the collection of additional surficial textural and morphological data, the assessment of sea floor habitat and the identification and enumeration of plant and animal species. Figure 5.6 shows an image of a sponge reef in Hecate Strait.

Figure 5.6 Sponge reef in Hecate Strait.

Seabed images can be collected from frame-mounted cameras dropped over the side of a ship, from still or video cameras mounted on a "fish" towed behind a ship, or from remotely operated or autonomous underwater vehicles. Remotely operated vehicles (ROVs) are controlled through a cable system connected to a surface support vessel, but can move independently of the surface vessel and are routinely used for route survey work. Autonomous underwater vehicles (AUVs) can operate independently of surface ships, but are still considered to be in the development phase. Submersible vessels, available for specialized projects, are generally too expensive for use in routine survey work.

Samples of seabed sediments are collected for a variety of uses including measurement of engineering

properties and indices, chemical analysis and biological assessment. Shallow sampling near seafloor is generally carried out using weighted core tubes dropped from a distance above the seafloor. If deeper sampling is required casing is lowered from a drill-ship so that a hole can be drilled to the required depths for intermittent sampling of soil and rock through the casing.

Recent advancements in seabed testing have been primarily in the area of in situ testing of geotechnical and acoustic seabed properties, minimizing the effects of sample disturbance encountered in more traditional sampling and laboratory testing approaches. In-situ testing is also more economical than the traditional methods based on sampling and laboratory testing and permits a more extensive sub-surface coverage of the study area in a given field program.

5.1.3.7 Seabed Sampling and In-situ testing

A variety of cone penetrometer tests (CPT) are available for in situ measurements of geotechnical properties of the seabed. In this approach, an instrumented probe with a conical tip is pushed into the seabed at a controlled rate. Engineering indices measured during a CPT can be correlated to soil strength, pore water pressure and resistance to liquefaction. Downhole seismic measurements can also be carried out during a CPT to assess soil behaviour under small-strain conditions.

In pressuremeter testing (PMT), a cylindrical inflatable probe is inserted into a borehole. The borehole can either be pre-drilled or a self-boring probe can be used. After insertion of the pressuremeter into the borehole, the probe is inflated with hydraulic fluid, allowing the stress-strain characteristics of the sediments to be measured in situ. In-situ pressuremeter testing can also be undertaken using a pressuremeter equipped with a cone penetrometer tip. Such a device is called the cone pressuremeter or full-displacement pressuremeter.

5.1.4 Information Technology

Steady and continuing progress over the last few years in information processing, both in terms of speed and volume has dramatically improved the ability of the oil and gas industry to conduct its exploration and development activities in a scientifically-based and predictable manner.

Improvements in signal processing and sensor technology have permitted the process of interpretation of geophysical data from the realm of art to that of science. Hardware and software capabilities have permitted successful exploration, development and production in more and more varied geological settings at reduced risk and greater economic benefit.

Given the increasing importance of industries in the information technology sector in British Columbia, the provincial economy is likely to benefit from the software, hardware and analytical services that may be procured by the oil and gas industry within the province.

5.1.5 Noise Issues in Geophysical Survey and Exploratory Drilling

Seismic survey is one of the loudest underwater noise-source (see Table 5.1). The effect of noise from seismic surveys and drilling on marine fauna has been the focus of intense research in recent years. The following sources provide outlines of these efforts in Australia and the US:

- www.appea.com.au/environment/proj_seismic.html; and
- www.gomr.mms.gov/homepg/regulate/environ/marmam/sperm_research.html.

Table 5.1 Sub-Sea Noise Levels

Noise Source	Max (dB)	Remarks	Reference
Undersea Earthquake	272 dB	M_l 4.0 (energy integrated over 50 Hz bandwidth)	Wenz, 1962.
Seafloor Volcano Eruption	> 255 dB	Massive steam explosions	Deitz and Sheehy, 1954; Kibblewhite, 1965; Northrop, 1974; Shepard and Robson, 1967; Nishimura, NRL-DC, 1995.
Airgun Array (Seismic)	255 dB	Compressed air discharged into piston assembly	Johnston and Cain, 1981; Barger and Hamblen, 1980; Kramer *et al.*, 1968.
Lightning Stike on Water Surface	250 dB	Random events during storms at sea	Hill, 1985; Nishimura, NRL-DC, 1995.
Seismic Exploration Devices	212-230 dB	Includes vibroseis, sparker, gas sleeve, exploder, water gun and boomer seismic profiling methods.	Johnston and Cain, 1981; Holiday *et al.*, 1984.
Container Ship	198 dB	Length 274 meters; Speed 23 knots	Buck and Chalfant, 1972; Ross, 1976; Brown, 1982b; Thiele and Ødegaard, 1983.
Supertanker	190 dB	Length 340 meters; Speed 20 knots	Buck and Chalfant, 1972; Ross, 1976; Brown, 1982b; Thiele and Ødegaard, 1983.
Blue Whale	190 dB	Vocalizations: Low frequency moans	Cummings and Thompson, 1971a; Edds, 1982.
Fin Whale	188 dB	Vocalizations: Pulses, moans	Watkins, 1981b; Cummings *et al.*, 1986; Edds, 1988.
Offshore Drill Rig	185 dB	Motor Vessel KULLUK; oil/gas exploration	Greene, 1987b.
Offshore Dredge	185 dB	Motor Vessel AQUARIUS	Greene, 1987b.
Humpback Whale	180 dB	Fluke and flipper slaps	Thompson *et al.*, 1986.
Bowhead Whale	180 dB	Vocalizations: Songs	Cummings and Holiday, 1987.
Right Whale	175 dB	Vocalizations: Pulsive signal	Cummings *et al.*, 1972; Clark 1983.
Gray Whale	175 dB	Vocalizations: moans	Cummings *et al.*, 1968; Fish *et al.*, 1974; Swartz and Cummings, 1978.
Open Ocean Ambient Noise	74-100 dB (71-97 dB in deep sound channel)	Offshore central CA; higher (≥ 120 dB) when vessels present.	Urick, 1983, 1986.

Source: atoc.ucsd.edu/ASTpg.html, see web-page for reference listing

Guidelines have emerged as a result of these research to minimize the effect of seismic survey on marine fauna (e.g., ISR, 2001; JNCC, 1998).

Noise issues on occupational health and safety have also been examined (e.g., HSE, 1999). As a result, it is recognized that the ambient noise exceeds the 90 dB limit applicable in the UK in isolated areas on the offshore oil and gas platform. Exploratory drilling activity is unlikely to elevate the ambient noise beyond 55 dB limits at a distance of 400 m (1,300 feet) from the drilling platform (US DOE, 1999). The workers' exposure to such a high noise level is therefore intermittent. Operational guidelines have developed from these efforts as outlined in CNSOPB (1998) and HSE (1999).

5.2 Drilling Technology in Offshore E&P

Following seismic survey and data analysis, an exploration and delineation drilling program is developed. A local geophysical survey and geotechnical investigation is undertaken around the proposed drilling locations to identify the geological and environmental hazards and risks, as discussed in Section 4, before finalizing the actual location. Exploratory drilling and production can be carried out using one of the following concepts.

Fixed Platforms, which are supported on the seafloor, provide excellent support for offshore oil and gas operations under various weather conditions. Fixed Platforms have been utilized in water depths of up to 1,000 m (3,300 feet) however the costs become excessive as depths increase. They include Jacket Barges and Jack-up Rigs (Figure 5.7).

Figure 5.7 Offshore Drilling Units

From left: Jacket Barge, Jack-up Rig, Semi-submersible Unit, Drill Ship, and a TLP with tie-backs

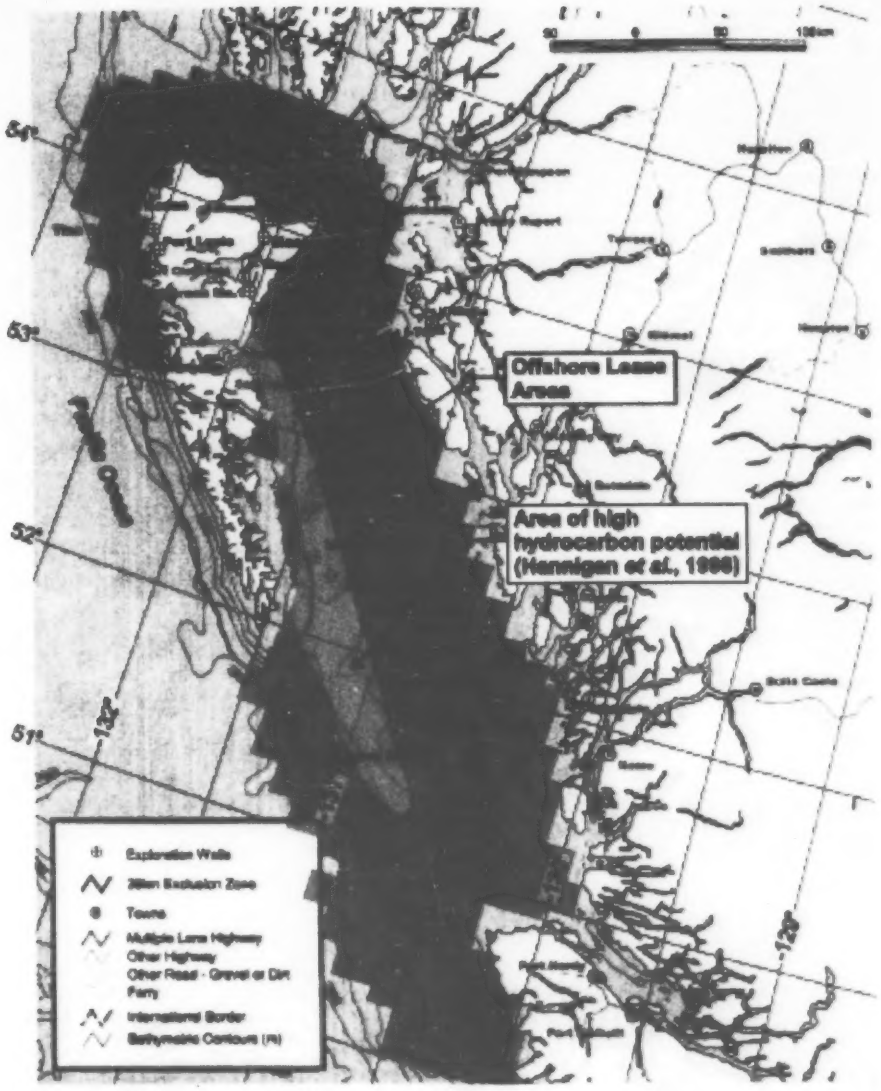


Figure 5.8 Water Depths in the Offshore Lease Areas

For deeper water or heavy loading conditions, large gravity structures have been utilized, e.g., Hibernia and Troll A. A fixed platform is amenable to retrofitting to accommodate changes in load carrying requirements and may therefore provide economical option to address potential future development issues. However, they are affected by seafloor stability and would require special provisions to account for earthquake and other geological hazards, or be located to avoid these problems. A further limitation of jacket barges and gravity structures is decommissioning costs at the end of field life. As shown in Figures 5.8 and 5.9, the water depths in the offshore lease areas around the Queen Charlotte Islands generally exceed 50 m (160 feet). Jacket barges are usually not employed where water depth exceeds 50 m. Such a platform would therefore be unsuitable in many potential target areas. The earthquake and tsunami hazards in these areas are also high. However, fixed gravity structures are being used in

areas of high earthquake hazard elsewhere. Hence, this concept may be suitable from an engineering perspective in the offshore areas around the Queen Charlotte Islands in the development and production phase.

The second option is based on Floaters, e.g., Tension Leg Platforms (TLP), Submersibles, Semi-submersibles, Spars, Truss-Spars, Single Column Floaters (SCF), Floating Production Storage and Offloading units (FPSO), and Drill Ships. Figures 5.7 and 5.10 illustrate of some of these designs. These units can be fabricated and transported to the wellhead for installation. The decommissioning of these units is simple. However, these units can only accommodate a smaller number of wells than a fixed platform and are less adaptable to the changes in load carrying requirements because of space constraint and stability issues. This option is likely to be favoured in the exploration phase around the Queen Charlotte Islands.

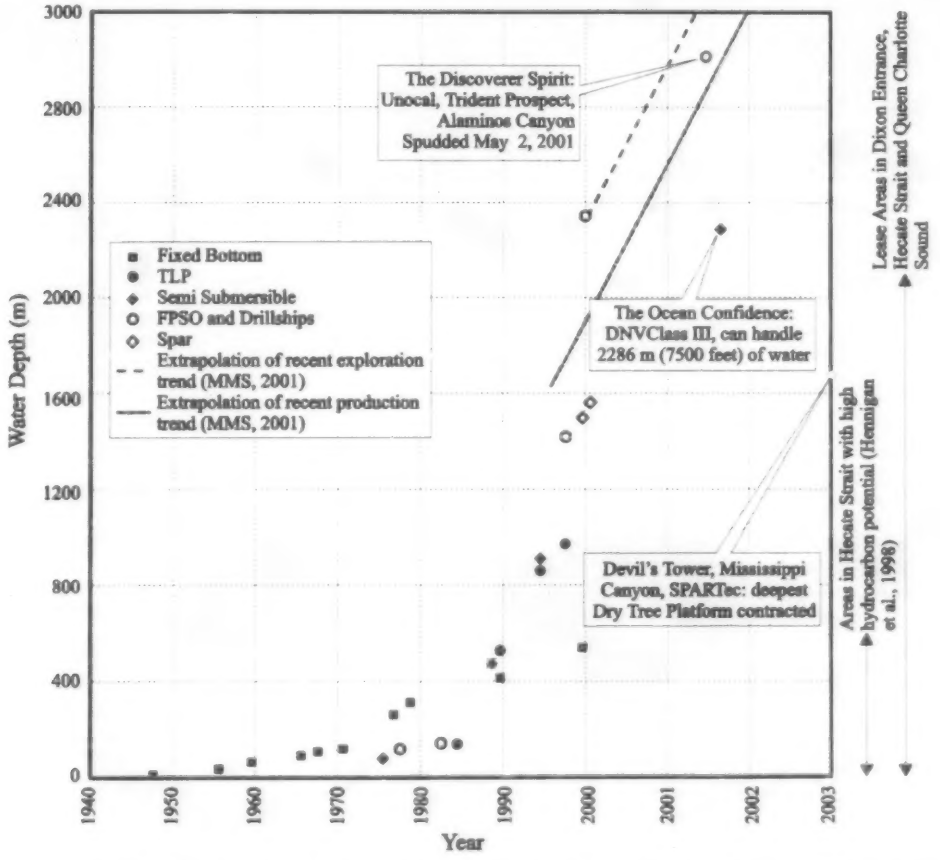


Figure 5.9 Water Depths in the Offshore Oil and Gas Exploration and Production

In subsea completion the wellhead and equipment such as a Blowout Preventer (BOP) stack are positioned on the seafloor and connected to the floating drilling vessel using a "marine riser." Subsequent production operations involve flow lines placed on the seafloor linked to a pipeline system

in case of gas or a floating production vessel in case of oil. In a dry-tree concept the wellhead equipment and accessories are supported on a platform above water.

In a conventional drilling program, a large diameter (about 1.1 m or 43⅓ inch) hole is drilled from seafloor to a depth between 30 and 60 m (100 and 200 feet) and a steel casing (or conductor) of slightly smaller diameter is inserted and cemented in place. Below that depth, a smaller diameter hole (about 650 mm or 25½ inch) is advanced to about 250 m (820 feet) depth and a casing of slightly smaller diameter is inserted and cemented in place. Up to this stage, drilling is generally carried out with seawater and a high viscosity polymer additive for hole-stability and the spent drilling fluid is returned to the seafloor. The BOP stack is then lowered on a marine riser and connected to the wellhead.

After wells are completed they are normally connected to, and operated from, a production facility that can be up to 60 to 100 km (40 to 60 miles) away from the well, leading to significant capital cost savings. These distances are limited by the water temperature (in cold water wax tends to come out of the hydrocarbon and collect on the inner surface of the pipe) and the wellhead pressure. Subsea completion and tieback is based on wet trees installed on the seafloor. An alternative concept is based on a dry-tree system that places wellheads above the well itself on fixed or floating platforms. Dry Completion Units (DCUs) serve as permanent drilling, work over and production units and are deployed in such a development with an FPSO unit (Clarke and Kaalstad 2001).

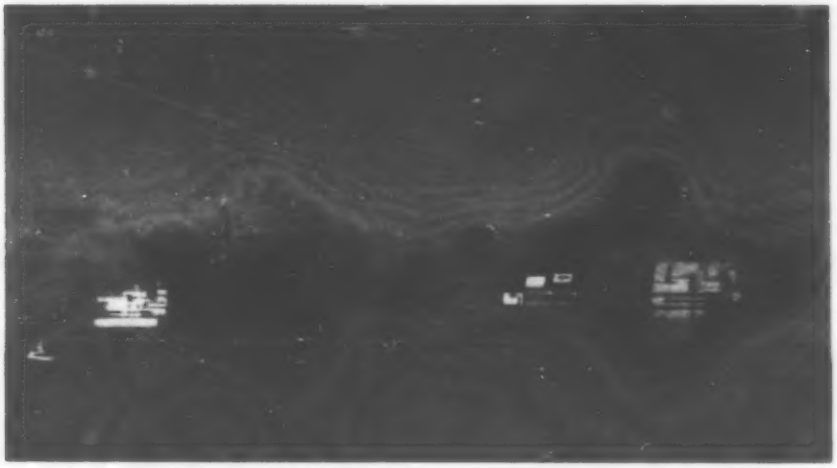


Figure 5.10 A Truss-SPAR Rig is Being Transported

The BOP prevents blowouts by controlling efflux of formation fluid out of well bore by sealing around the drill pipe. With the marine riser connected, drilling proceeds further with drilling fluid returned to the drill rig for analysis, recycling and treatment. "Zero discharge" drilling can be undertaken from this stage in environmentally sensitive locations (see SCCRWP 1993), which prevents drilling mud discharge into the sea.

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APPENDIX 1

SUMMARY OF DFO'S HADD COMPENSATION PROCESS

Any project that is referred to DFO is reviewed to determine if there is likely to be a HADD to productive fish habitat as defined under Section 35 of the *Fisheries Act*. DFO have a hierarchy of preferred options to avoid a HADD. These are, in order of preference:

- **relocation** or physically moving a project, or part of a project, to eliminate adverse impacts on fish habitat;
- **redesign** of a project so that it no longer has negative impacts on fish habitat;
- **mitigation** of impacts in cases where relocation and redesign are not possible; or
- **compensation**, which involves replacing damaged habitat with newly created habitat or improving the productive capacity of some other natural habitat.

Compensation is DFO's least preferred option and as such, should only be considered when relocation and redesign prove impractical and where mitigation measures fail to avoid a HADD.

Once a HADD is determined to occur, and it cannot be avoided by the first three options above, the federal Fisheries Minister, under Section 35(2) of the *Fisheries Act*, must authorize the HADD or the project cannot proceed. The authorization may be granted on the condition that losses to habitat caused by the project must be balanced by gains elsewhere. This requirement stems from DFO's Policy for the Management of Fish Habitat, which states that there shall be no net loss of fisheries habitat. A quantification of the potential HADD, proposed compensation, a schedule and any required follow-up will be detailed in a Compensation Plan developed by the Proponent. Based on this plan, a legally binding Compensation Agreement will be entered into by the Proponent and DFO and the agreement will be appended to the authorization granted by the Minister. The requirement for an authorization is a *CEAA* trigger that initiates a federal environmental review.
The amount of HADD is usually quantified based on known project activities that have a defined 'footprint' that will disrupt, damage or alter fish habitat (i.e., seabed). This can include construction of glory holes, installation of subsea infrastructure, installation of pipelines, etc. The total surface 'footprint' area that is affected by project activities is calculated. To complete the environmental review, DFO requires an acceptable habitat compensation strategy to be developed. The habitat compensation strategy provides alternatives that could be used to compensate for lost habitat.

Alternatives that would provide habitat compensation should be considered in terms of a hierarchy of preferred compensation options:

- create similar habitat at or near the development site within the same ecological unit;
- create similar habitat in a different ecological unit that supports the same stock or species;
- increase the productive capacity of existing habitat at or near the development site and within the same ecological unit;
- increase the productive capacity of a different ecological unit that supports the same stock or species; or
- increase the productive capacity of existing habitat for a different stock or a different species of

fish either on or off site.

Compensation may not be an option for particularly valuable habitat.

In some cases, more than one alternative may be used in a single project to protect and maintain habitat capacity to produce fish. Once agreement has been reached for a habitat compensation strategy, the Proponent than prepares a Habitat Compensation Plan, which provides specific information on the selected strategy (and transmits that information to the public) and details how the strategy will be implemented and monitored.

Examples of marine habitat compensation plans in Atlantic Canada include the:

- construction of a reef to provide lobster habitat in the vicinity of a wharf constructed for the Newfoundland Transshipment Terminal (which provides on-land storage for crude from the offshore platforms prior to second-leg tanker transport to markets); and
- creation of nearshore habitat for Iceland scallops to compensate for offshore Iceland scallop habitat lost due to the excavation of glory holes and burial of a seabed pipeline for the Terra Nova development (offshore Newfoundland).

APPENDIX 2

FIRST NATIONS POSITIONS ON THE OFFSHORE OIL AND GAS MORATORIUMS

Press Release

Tsimshian and Haida Statement on the Moratorium on North Coast Oil and Gas Exploration

May 14, 2001

The Tsimshian Nation and the Haida Nation continue to support the Moratorium on Offshore Oil and Gas Exploration. The Tsimshian and Haida have examined the issues and determined that the reasons cited for initiating the Moratorium have not changed. "The petroleum interests that are being promoted are within the territorial seas of our people, says Deborah Jeffrey, President of the Tsimshian Tribal Council "Our culture and identities are integrally tied to our land and seas, including the marine resources."

The cultures of Northwest Coast peoples are derived from their relationship with their lands. The marine environment is amongst the richest on the planet while the coastal rainforests attract visitors from around the world. "The risk of harm from an accidental spill or from allowable discharge is not acceptable and they expect us bear the risk, says Guujaw, President of the Council of Haida Nation. "We intend to pass on a life and culture to the following generations which includes fish and birds."

The position of the Tsimshian and the Haida is consistent with the position of the federal government. The Environment Minister David Anderson stated previously in the media dated August 9, 2000: "I am not going to in any way support lifting of the moratorium until it's clearly shown that the reasons for having it in the first place are no longer valid." He stated interested parties would have to satisfy concerns about the environment, the fishery, earthquakes and aboriginal involvement in any proposal.

Deborah Jeffrey, President of the Tsimshian Nation and Guujaw, President of the Haida Nation are united in their statement to the federal and provincial governments, "The Moratorium on Offshore Oil and Gas Explorations must remain in place."

For further information:

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SPEAKING NOTES - GARRY REECE
OIL AND GAS CONFERENCE
OCTOBER 2, 2001

Thank you for inviting me to speak at this important conference. These are significant issues before us, and I appreciate the recognition that First Nation involvement is essential to any suggestion that development can proceed under any conditions.

I'd like to start by referring you to the official joint position of the Tsimshian Tribal Council and the Haida Nation, which opposes oil and gas exploration and development in our waters at this time. We are full members of the Tsimshian Tribal Council, but I should note that I represent only the Lax Kw'alaams Band at this meeting, and my comments come only from myself as Chief of that Band.

THE LAX KW'ALAAMS BAND

As the elected Chief of the Lax Kw'alaams Band, let me tell you more about our Band for those of you who are not familiar with us.

- we are one of BC's largest bands
- with approximately 2,700 members; 1300 live in the Village of Lax Kw'alaams, at Port Simpson, north of Prince Rupert, which is accessible only by ferry and air service
- the Band has jurisdiction over 72 reserves totalling some 11,800 hectares of land.
- separately governed (an elected council and Hereditary system) but also a member of the Tsimshian Nation; full participants in the Tsimshian Tribal Council
- our membership consists of nine of the fourteen tribes of the Tsimshian Nation
- have occupied the north coast since time immemorial, there is evidence of 5,000 years of occupation in the Prince Rupert area
- The Lax Kw'alaams are in Treaty process, as a member of the Tsimshian Tribal Council, but are not yet at the Approval in Principle stage. (Things, as you know, are going slowly, and the current approach of the Lax Kw'alaams Band is not to stake our future on this process. We intend to move forward through economic development initiatives to become completely self-sufficient)

The Lax Kw'alaams Band have long been participants in the modern economy. The Band has business interests:

- in commercial fishing
- participated extensively in the commercial salmon, halibut, herring and other fisheries since the commercial fishery started,
- set up Lax Kw'alaams Marine Industries which operated a cannery ever since the 1970's
- participated in joint ventures with fish processing companies, (currently one is active)

- and logging:
- set up the Lax Kw'alaams Development Corporation which engaged in logging on reserve through the 1980's and 1990's
- set up and operates Tsimskow Resources Ltd. which does contract logging and silviculture sub-contracting, and a non-replaceable 10 yr Forest Licence with a significant volume.

- and we're also no stranger to the Oil and Gas industry, and not adverse to doing business: In the 1980s the Band entered into a comprehensive agreement with Dome Petroleum regarding the development of a liquid natural gas plant, which was ground-breaking at the time, and one that showed the industry that reasonably progressive relationships are possible.

Reliance on the Sea

For us the sea is not an "industry", it is our life. Our people have traditionally relied on the ocean for a very wide variety of resources – from salmon, herring, groundfish, to abalone, sea urchin, kelp etc.

We fish commercially, it is still our largest source of employment, it is still the basis of our culture. Its value cannot be measured in money.

Each of these activities, all of which have their own seasons, and each of which have traditional practices, modern methods and commercial implications, are potentially impacted by both the possibilities of lower-level chronic impacts, and by the possibility of a catastrophic spill.

Consideration of the Full Risks to First Nations

I am not a scientist, but I do know something of the wide variety of possible negative effects of the proposed developments. I will leave it to others to talk of these in detail. But issues for us that would suggest that oil and gas development could be unacceptable or possibly devastating to us include:

- the sensitivity of the Coastal environment in general
- the salmon and other commercial fisheries
- Seismic exploration and noise effects on the marine environment
- Groundfish and other less mobile species
- General toxic effects on wildlife, sea mammals like otters and seals
- the Big Spill (even low risk is unacceptable if impacts are devastating)
- The negative effects on other economic development alternatives – eg. tourism, alternative fisheries, acquaculture etc.

I note however, that for us, this issue is not limited to environmental or technical matters -- primarily perhaps this is a social issue. From a whole range of possibilities, our culture is put at risk, not only from any disaster, or environmental impacts, but also by the possible changes that large industrial activity will bring to us.

Also, please do not suggest that the risk of exploration are lower than that of production. That may indeed be true, but we know this: if exploration produces significant developable reserves, they will be developed. The pressures for development will be huge. Why look for oil and gas unless you intend to produce it.

The Benefits – How much would really come to First Nations?

Any analysis that was intended to justify such risks, would, it is fair for any government to say, have to be justified by a clear cost-benefit analysis, and one that ensured that the provable and certain benefits clearly outweighed the risks – the benefits to us, and the risks to us.

We are told there are very significant economic benefits to be obtained from oil and gas development, and these will be shared fairly with First Nations. We are told that the risks can be mitigated, and that science and technology have evolved to the point where there is no risk.

We have one thing to say to this: "PROVE IT".

Promises and good intentions will never be enough to put our way of life and our lands at risk.

Do you wonder that First Nations should be suspicious?

- If you look at the history of the crisis in our fisheries and the so-called scientific management of salmon and other species;
- If you look at forestry and mining, and how few benefits have gone to First Nations;
- If you look at the general process of "consultation" and how little difference it has made to most decisions;

the wonder is not that First Nations would be cynical, the wonder is that First Nations representatives like myself might still have an open mind, might still be willing to discuss these issues.

If we look to the experience in B.C. with forestry, with mining, with the fishery, even if we look to Northeastern B.C. and the oil and gas there, we do not see an overwhelming history of fairness in the distribution of resource opportunities, opportunities that once belonged exclusively to our nations.

First Nations do not want to have a few of their members employed in your operations. Yes, we need employment, but such employment alone is insufficient, and can even be disruptive of our culture and communities. First Nations today want an ownership stake in the businesses and opportunities that arise, we want revenue sharing, and an effective role in decision making. We want to be full and active participants if we would ever accept the very substantial risks to our lands and resources and way of life that this activity suggests.

Do not make the mistake of assuming that First Nations have a knee-jerk and uninformed opposition to oil and gas exploration. Yes, we have an immediate and fundamental realization of the potential risks. But Band governments like ours also have the capacity to make sophisticated decisions, based on science and business. We have the capacity to make decisions with an open mind (but with open eyes as well, and full awareness of past lessons). But, where significant risks exist that will primarily be borne by us, do not expect us anymore to make these decisions without a full assessment of these risks.

Need for First Nations-led investigations

And perhaps more importantly, do not assume that we will be satisfied by the investigations controlled by others, whether it is government sponsored Environmental Assessment Panels, or inquiries, or by company-led scientific consultant reports, or particularly by the current proposed provincial government process.

Those who will bear the risks should make the assessment.

First Nations have legal and moral rights in the coastal areas on which exploration would occur. We are the major users of marine resources. Outside of the cities, we are the primary inhabitants of most of the coastal areas. We are the ones who will suffer the risks. We do not intend to allow this exploration or development to proceed <u>unless it has our full consent</u>.

And I cannot contemplate that we would ever give our consent until we had conducted our own investigation of all the facts in a manner we could trust.

<u>The inadequacy of Consultation</u>

Do not make the mistake that governments and other industries have made in thinking that simple "consultation" will satisfy our concerns. 'Consultation' has become a dirty word to many First Nations because it usually occurs after industry has formulated its plans, after it has spent years in planning and talking to government, after decisions in principle have been made and, generally, far too late to have any honesty or integrity. Such consultation is designed to soothe First Nations, to convince us that real risks are not real, that real harms are not harmful, and to buy our acceptance of the inevitable for bits and pieces and pennies on the dollar. First Nations have come to realize that no matter how friendly and decent the bureaucrat who comes to consult, no matter how lengthy the process, there is little value in such consultation.

In the past, First Nations received 'Trinkets and Beads' for valuable goods or lands – that is no longer something which we will accept.

<u>Need for Dialogue Now</u>

We are told that the Canadian Association of Petroleum Producers and companies like PetroCanada and Shell have confirmed that they will not be involved in activity off our coasts until land claim issues are settled. If they are sincere, we applaud them. Of course, if they are honest in waiting for Treaties, at the rate that process is going, we may all be waiting a very long time.

But even then, I caution industry that they should not, must not, wait until that time, and then expect to proceed without First Nations involvement. It is very much in the interest of everyone to have honest dialogue now, if you ever wish to proceed in good faith.

If there is one piece of advice I can give industry (and government), it is this: If you want to do business in First Nation lands, on our coasts, in our seas – We must be involved and we must be involved at the front end. You must start working with us BEFORE you complete the planning process, before or at least in parallel with your consultations with other governments.

You need to start working with First Nations now, you need to spend as much money and effort understanding us and our use of the sea and our lands, as you do understanding the geology and the environmental and technical challenges. You need to work with us to understand the very real risks. You need to ensure that the benefits you propose are real and substantial, and are real and substantial to the First Nation communities who inhabit the area. And most importantly, you need to respect us, and respect our rights, and respect our decision making processes. Then, perhaps, we can do business in a way that works for you, and for us.

Thank you.

APPENDIX 3

SUMMARY OF CUMULATIVE EFFECTS ASSESSMENT FOR OFFSHORE OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITIES IN US FEDERAL WATERS

Environmental Component	Other Projects and Activities	Conclusions
Source Document/EIS: OCS Environmental Assessment. Extended-Reach Exploratory Drilling Project		
Air Quality	• On-going oil and gas activities. • Marine Shipping and Tankering	Insignificant increase to overall cumulative air quality No cumulative impacts expected to regional air quality
Marine Water Quality	• On-going oil and gas activities • Intermittent River Run-off	No incremental additive effect
Fish Resources	• On-going oil and gas activities • Dredging • Discharge of Dredged material • Water-intake structures • Aquaculture • Wastewater Discharge • Oil and Hazardous Waste Spills • Coastal Development • Agricultural Run-off • Commercial fishing • Recreational fishing	Impacts from the proposed project are not expected to add measureably to cumulative impacts
Protected Areas		Refer to other sections
Source Document/EIS: Delineation Drilling Activities in Federal Waters Offshore Santa Barbara County, California: Draft Environmental Impact Statement (2002-2006 Timeframe)		
Air Quality	• On-going and proposed oil and gas activities • Natural petroleum seeps • Marine shipping and tankering	The potential is low for incremental emissions to add to cumulative impacts to air quality (low = insignificant)
Water Quality	• On-going and proposed oil and gas activities • Municipal and industrial wastewater discharges • River run-off • Oil Spills	The discharge of drilling muds and cuttings may overlap in space and time with other projects or activities Oil spills may result in short-term moderate (significant) impacts, and long-term low (insignificant) impacts Incremental impacts from the proposed project are low (insignificant)
Seafloor Resources	• On-going and proposed oil and gas activities • Commercial fishing • Fiber cable installation • Sediment and contaminant	Overall impacts to high relief hard bottom habitat are high from all sources, particularly commercial fishing activities. Irreversible habitat alteration resulting from the proposed projects could occur from anchoring activities. Overall impacts to soft bottom resources is low

Environmental Component	Other Projects and Activities	Conclusions
Fish Resources	• On-going and proposed oil and gas activities • Tankering • Military operations • Dredging • Discharge of dredged material • Aquaculture • Coastal development • Agricultural runoff • Commercial fishing	The proposed project will add a negligible increment to the overall cumulative effects on fish resources
Marine mammals	• On-going and proposed oil and gas activities • Oil spills • Military Activities • Commercial Fisheries • Other Anthropogenic Activities (e.g., vessel strikes, marine pollution) • Non-anthropogenic (e.g., disease)	The incremental contribution of the proposed project on cumulative effects is expected to be negligible to low (insignificant)
Threatened and Endangered Species	• On-going and proposed oil and gas activities • Oil spills • Military Activities • Commercial Fisheries • Other Anthropogenic Activities (e.g., vessel strikes, marine pollution) • Non-anthropogenic (e.g., disease)	The incremental contribution of the proposed project on cumulative effects is expected to be negligible to low (insignificant) Negligible to low (insignificant) impacts may occur to blue, fin, and humpback whales from the proposed project. No impacts are expected to sei, right or sperm whales, Steller sea lions, Guadalupe fur seal, or southern sea otters Negligible impacts to sea turtles as a result of the proposed project is expected.
Protected Areas		No impact is expected
Cultural resources		No impact is expected
Source Document/EIS: Delineation Drilling Activities in Federal Waters Offshore Santa Barbara County, California: Draft Environmental Impact Statement (2002-2030 Timeframe)		
Air Quality	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Marine shipping and tankering	Level of effect is speculative and uncertain A more comprehensive review is required as oil and gas developments progress
	• Oil Spills	Localized, insignificant
Water Quality	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • River input • Sewage Treatment plant Discharge	Low Impact

Environmental Component	Other Projects and Activities	Conclusions
Rocky and Sandy Beach Habitat	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Storm Events • Warm water trends • Natural seeps • Public use	Moderate to high impacts (significant) in Southern California Low to moderate (insignificant to significant) impact to the north
	• Oil Spills	Low to High impact, depending on location and size of spill
Seafloor Resource	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Trawling • Fibre optic cable installation	Low to moderate impacts, depending on whether hard bottom habitat is affected
Kelp Beds	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Warm water trends • Commercial fishing • Vessel traffic • Discharges	Incremental impact of oil and gas development is low
Fish resources	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Commercial fishing • Water Pollution • Habitat degradation	Cumulative impacts to fish resources as a result of oil and gas development are expected to be moderate (significant)
	• Oil spill	The incremental increase in a risk of an oil spill represents a measureable overall cumulative oil spill risk
Marine and Coastal Birds	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Helicopter traffic • Climate events • Pollution • Habitat Loss • Predators • Commercial fishing • Human disturbance	Routine operations of oil and gas development will not contribute to cumulative effects on birds
	• Oil Spills	Moderate to high impact

Environmental Component	Other Projects and Activities	Conclusions
Threatened or endangered species	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Storm Events • Warm water trends • Trawling • Fibre optic cable installation • Commercial fishing • Helicopter traffic • Vessel traffic • Discharges • Natural seeps • Public use	Cumulative impacts from routine oil and gas activities to threatened and endangered marine mammals are expected to be low. Most activities from routine oil and gas activities would not contribute to cumulative effects to threatened and endangered bird species; oil spills and disturbance from helicopter flights range from low to high. Cumulative impacts from routine oil and gas activities to threatened and endangered sea turtles are expected to be negligible. Cumulative impacts from routine oil and gas activities to threatened and endangered amphibians are expected to be negligible Cumulative impacts from routine oil and gas activities to threatened and endangered fish species are expected to be low Most activities from routine oil and gas activities would not contribute to cumulative effects to threatened and endangered plant species; oil spills and construction of onshore facilities range from low to high.
	• Oil Spills	The cumulative impact of an oil spill to threatened or endangered species ranges from low to high, depending on the size, location, timing, and duration of the spill.
Marine Mammals	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Commercial fishing – incidental take • Ship strikes • Pollution • Shipping (Noise) • Military Activities (noise)	Cumulative impacts from routine oil and gas activities are expected to be low
	• Oil spills	Negligible to high, depending the location,, size and duration of the oil spill

Environmental Component	Other Projects and Activities	Conclusions
Estuarine and Wetland Habitats	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Storm Events • Warm water trends • Trawling • Fibre optic cable installation • Commercial fishing • Helicopter traffic • Vessel traffic • Discharges • Natural seeps • Public use • Commercial and residential development	Cumulative impact of oil and gas activities is low Overall cumulative effects from all activities ranges from low to high
Onshore Biological Resources	• Future oil and gas developments (including construction, pipeline installation, and decommissioning) • Storm Events • Warm water trends • Fibre optic cable installation • Helicopter traffic • Discharges • Public use	Cumulative effects from all activities is low to moderate.
Source Document/EIS: Liberty Development and Production Plan – Volume 1: Draft Environmental Impact Statement		
Endangered Species (Bowhead whales, Eiders, Other species)	• On-going oil and gas development activities • Transporting oil through the Trans-Alaska pipeline • Tankering from Valdez • Vessel traffic • Subsistence hunting	The incremental contribution of the Project to cumulative effects is likely to be quite small (not significant) Some bowhead whales may temporarily avoid noise-producing activities
	• Oil spills	A large offshore oil spill could increase adverse cumulative effects to potentially significant population levels
Seals and Polar Bears	• On-going oil and gas development activities • Transporting oil through the Trans-Alaska pipeline • Tankering from Valdez • Sport harvest of Wildlife • Commercial fishing • Subsistence hunting • Habitat alteration	The incremental contribution of the Project to cumulative effects is likely to be quite small (not significant) The Project should only briefly and locally disturb or displace a few seals or polar bears

Environmental Component	Other Projects and Activities	Conclusions
Marine and Coastal Birds	• On-going oil and gas development activities • Transporting oil through the Trans-Alaska pipeline • Tankering from Valdez • Sport harvest of Wildlife • Commercial fishing • Subsistence hunting	The incremental contribution of the Project to cumulative effects is likely to be quite small (not significant) Collisions with structures may occur, but losses are expected to be low
	• Oil Spills	Significant effects could occur to some populations, with particular note to the long-tailed duck and common eider
Terrestrial Mammals	• On-going oil and gas development activities • Transporting oil through the Trans-Alaska pipeline • Tankering from Valdez • Sport harvest of Wildlife • Commercial fishing • Subsistence hunting • Habitat alteration	The incremental contribution of the Project to cumulative effects is likely to be quite small (not significant) Some caribou may be displaced (represents less than 1% of the local short-term disturbance of caribou) The Project should only briefly and locally disturb or displace a few muskoxen and grizzly bears
Lower trophic-level Organisms	• On-going oil and gas development activities	The incremental contribution of the Project to cumulative effects is likely to not be measureable (not significant)
Fishes and Essential Fish Habitat	• On-going oil and gas development activities	The incremental contribution of the Project to cumulative effects is likely to not be measureable (not significant)
	• Oil Spills	The incremental contribution of the Project to cumulative effects is likely to not be measureable on fish populations (not significant)
Vegetation-Wetland Habitats	• On-going oil and gas development activities • Oil Spills (minor issue)	The incremental contribution of the Project to cumulative effects is likely to be less than 1% of the cumulative disturbance effects (not significant)
Archaeological resources	• On-going oil and gas development activities	The incremental contribution of the Project to cumulative effects is likely to be minimal (not significant)
Water Quality	• On-going oil and gas development activities	Sediment effects are expected to be short term, having the greatest impact in the immediate vicinity of the activity Regional long-term, degradation of water quality to levels above regulated criteria due to hydrocarbon contamination is very unlikely
	• Oil spills	A large spill (greater than 500 barrels) would have a significant effect
Air quality	• On-going oil and gas development activities	Air emissions from the Project essentially

Environmental Component	Other Projects and Activities	Conclusions
	• Tankering from Valdez	would have no effects on air quality Projects in the past and present have caused essentially no deterioration in air quality or contribute measureably to global climate change.

Source: MMS 2000; 2001a; 2001b